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A Summary of Current Program and
Preliminary Report of Progress

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VEGETABLE RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

December 1, 1963

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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)

Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering
Crops
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- | | |
|--|--|
| 1 - Cross Commodity Research of
Agricultural Engineering, Crops,
& Entomology Research Divisions | 7- Cross Specie & Miscellaneous
Animal Rssearch |
| 3 - Rural Dwellings | 8- Cotton and Cottonseed |
| 6 - Forestry (Other than Forest
Service) | 8- Tobacco |
| 7 - Beef Cattle | 9- Grain and Forage Crops |
| 7 - Dairy | 10- Citrus and Subtropical Fruit |
| 7 - Poultry | 10- Deciduous Fruit and Tree Nut |
| 7 - Sheep and Wool | 10- Potato |
| 7 - Swine | 10- Vegetable |
| | 10- Florist, Nursery & Shade Tree |
| | 11- Oilseed and Peanut |
| | 11 - Sugar |

A copy of any of the reports may be requested from Roy Magruder, Office of Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

This report deals with research on all the vegetables except white or Irish potatoes. It does not include extensive cross-commodity work, much of it basic in nature, which contributes to the solution of problems of agricultural commodities, as well as those of vegetables. The progress in cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA PROGRAM, (3) REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS for the past year, and (4) PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH.

Research on vegetable problems is supported by (1) Federal funds appropriated to the research agencies of the USDA (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by USDA

Farm Research

Farm research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, crop pest control techniques and equipment and electromagnetic and ultrasonic energy for insect control and other farm uses. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1963 involved about 82 professional man-years.

Nutrition, Consumer and Industrial Use Research

Nutrition and consumer use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service, and in fiscal year 1963 involved 19.2 professional man-years. Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of vegetables with other foods. It is also concerned with improved equipment and processes. The work is conducted by the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; the Southern Utilization Research and Development Division, New Orleans, Louisiana;

INTRODUCTION (Cont.)

the U S. Fruit and Vegetable Laboratories at Weslaco, Texas, and Winter Haven, Florida; the U S. Food Fermentation Laboratory, Raleigh, North Carolina; the Western Utilization Research and Development Division, Albany, California; the Fruit and Vegetable Products Laboratories at Puyallup and Prosser, Washington; and the Fruit and Vegetable Chemistry Laboratory at Pasadena, California, and under contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1963, the work involved about 63.5 professional man-years.

Marketing and Economic Research

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service. Economic research is concerned with marketing costs, margins and efficiency; market potential, supply and demand; outlook and situation; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 32 professional man-years were devoted to marketing and economic research in fiscal year 1963.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by food processors and distributors, food industry and trade associations, seedsmen, chemical and fertilizer companies, marketing equipment and facility manufacturers, package and container manufacturers, market research institutes and corporations and growers (individually and through their associations).

INTRODUCTION (Cont.)

Industry's cooperation in supporting research on vegetables in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State Stations has contributed greatly to its success.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried vegetable products. The canning, freezing and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at USDA laboratories, universities, and other organizations. Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling vegetables on the farm, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which they are moved and on the transportation vehicles from which they move from one point in the distribution channel to another. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and inter-regional and intermarket competition.

Chemical and fertilizer companies are significant factors in research on the development of new materials or combinations of materials to produce more efficiently, high quality vegetables through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds, killing of tops, and protective waxes.

Several of the large vegetable seed producers and some of the vegetable processors have staffs of scientifically trained and competent plant breeders, seed technologists and horticulturists who are capable of using the basic research results and disease and insect resistant breeding stocks produced in Federal and State laboratories, in the production of commercial varieties locally, regionally, or nationally adapted. In time it should, therefore, be possible for public agencies to restrict their work on the production of finished varieties of vegetables and to shift the resources now employed in breeding varieties to more of the fundamental work on isolating resistance factors, determining the manner of their inheritance and on the development of breeding methods to most efficiently use them.

It is very difficult to estimate the contribution of growers to our overall research effort on vegetables. Certainly, in the field of production his help is indispensable for most of the laboratory and

INTRODUCTION (Cont.)

trial ground research results must finally be confirmed by field experiments. The grower cooperates with the USDA, State Experiment Stations and suppliers of many materials and equipment; usually, without compensation except for the experience and knowledge gained.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Sanilac, A Disease-Resistant Dry Bean. Michigan bean growers obtained approximately \$50 million for their 1962 dry bean crop, the highest dollar return from this crop in the history of the Michigan bean industry. The record was broken not only dollar-wise but also from the production standpoint, with 7-1/2 million 100-pound bags being produced. This is about 40 percent of the nation's dry bean crop. Much of this gain can be attributed to introduction of the disease-resistant Sanilac variety pea (navy) bean, jointly released in 1956 by the U.S. Department of Agriculture and Michigan State University. In 1962, Michigan growers produced over 99 percent of the pea beans of the United States and of these 80 percent, or 5,580,000 bags, were Sanilac.

Volume growth achieved in production of milky disease bacteria for control of Japanese beetle. Department research has demonstrated the feasibility of growing milky disease bacteria on a large scale in the vegetative form by submerged culture fermentation on grain-based media. The next step in development of this control agent for Japanese beetle is to obtain sporulation under industrially practicable conditions. So far, some success has been obtained in securing sporulation, but only on a solid medium. These and other studies have provided important new information on nutrients, bacterial metabolism, and previously unsuspected growth factors that should provide the basis for successful attainment of the objective. Work is continuing both in-house and by contract on all aspects of the problem.

Spores of milky disease bacteria induce the disease in Japanese beetle grubs and thus provide the best nonchemical agent now known for control of this serious plant pest. At present, spores must be obtained by the costly procedure of isolating them from infected grubs. Volume production of spores by industrially acceptable fermentation procedures would make this biological insecticide, which leaves no dangerous residues and is harmless to man and animals, an economical material for general use.

Sex attractants--a new approach to insect control. The isolation, identification and synthesis of the powerful sex attractant found in gypsy moth females represents a break-through in research on the development of highly specific methods for insect detection and opens the way for a new desirable approach to insect control. The attractant produced by virgin female American cockroaches has been isolated and identified. Recent research has shown that virgin female adults of

INTRODUCTION (Cont.)

several major pests, including the European corn borer, house fly, cabbage looper, cotton leafworm, pink bollworm, tobacco hornworm, tobacco budworm, cockroaches, peach tree borer, lesser peach tree borer, and banded cucumber beetle, contain specific sex attractants. Research on methods of isolation and on the chemical composition of the natural attractant substances that is now underway should lead to their future synthesis.

Nondestructive Measurement of Interior Quality of Fruits, Vegetables and other Commodities. Techniques and equipment have been developed for making measurements of the spectrum of light transmitted through intact fruits and vegetables. These measurements have led to the development of methods to measure the maturity of peaches, apples, plums, and other fruits, to detect black-spot of potatoes, water core or other internal disorders of apples, and blood spots in eggs. Methods can be made available whereby the non-conforming specimens are automatically removed from the packaging lines.

I. FARM RESEARCH

CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. One of the important needs in a more efficient agriculture is the development of improved planting material with resistance to insects, diseases and climatic hazards, increased adaptation and higher quality. There is a need to search out, introduce and evaluate the widest possible genetic base of vegetables that may be of value as varieties or breeding materials.

USDA PROGRAM

The Department undertakes a continuing program of plant introduction, evaluation and maintenance. The research involves botanists, horticulturists and plant pathologists who are engaged in both basic and applied studies that will provide plant scientists and others with documented germ plasm.

Plant introduction is undertaken in both foreign and domestic fields, either through direct exploration or international exchange. Taxonomic and economic botanical research on world plant resources, development of national inventories of introduced stocks, coordination of foreign and domestic plant collecting, and botanical assessment of the results of crop utilization screening programs are conducted at Beltsville. Cooperative arrangements with the four regional projects provides for domestic explorations.

Evaluation of vegetable stocks is done at Beltsville, Maryland; Glenn Dale, Maryland; Experiment, Georgia; Savannah, Georgia; Miami, Florida; Chico, California; Geneva, New York; Ames, Iowa; and Pullman, Washington. It involves observations for specific characters needed in varietal improvement, the maintenance of collections of important foreign varieties, and limited increase to provide material for testing purposes. Regional station pathologists screen the introductions for disease tolerance. Federal, State and private breeders cooperate in the early evaluation of introductions. Needs for additional breeding stocks are assessed by the research leaders at Beltsville and become the basis for future plant exploration and introduction.

The Federal scientific effort devoted to research in introduction and evaluation of vegetables is 3.8 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Foreign exchange with the USSR and satellites accounted for 396 introductions, including a large group of alliums. A large collection of *Phaseolus* was received from Chile and 300 capsicums from Latin America.

P.L. 480 projects provided 93 lots of *Citrullus* and 50 lots of *Lactuca* seeds.

In 1962, 1,916 vegetable introductions were distributed to Federal and State research workers, largely through the regional plant introduction stations.

Waterchestnut research at Savannah showed that nitrogen is the key nutrient in production. Increase in production is significantly correlated with rate of N. At an experimental rate equal to 200 lbs/acre of N, the yield was equivalent to 22,550 lbs. of corms/acre. At least one commercial company has attempted trial plantings of waterchestnut with excellent growth and yield.

Under the regional cooperative programs, plant introductions were used in the development of several new vegetable varieties as follows: A new tomato variety 'Marion' released by the South Carolina Agricultural Experiment Station owes resistance to fusarium and stemphyllium wilt to *Lycopersicon pimpinellifolium*, P.I. 79532 (Peru). (S-9.) The 'Porte' tomato released by Crops Research has inherited similar resistance from this same introduction and the Florida Agricultural Experiment Station developed 'Floralou' with P.I. 79532 and P.I. 126445 (Peru) (*L. hirsutum*) as sources of multiple disease resistance. (S-9.) 'Epoc,' a tomato released by Purdue University also owes its disease resistance to P.I. 79532. (NC-7.) The Oregon AES has developed a tomato 'German Cherry' selected from P.I. 180725 (Germany). (W-6.) Idaho AES developed a new pepper variety 'Idabelle' of which a single plant selection of P.I. 206949 (Turkey) was one parent. (W-6.)

In melon varietal improvement, 'Floridew,' released by the Florida AES, is considerably resistant to powdery and downy mildew through its parent, P.I. 223637 (Iran). (S-9.) In the case of gummy stem blight, however, screening of commercial varieties and plant introductions showed that 4 out of 10 commercial varieties had a satisfactory level of resistance and were as resistant as any foreign introductions tested. (S-9.)

Plant introductions were also screened as to their desirability as basic breeding stocks and several were reported this year as follows: P.I. 246502 (Peru) *Solanum pennellii*, is resistant to several important tomato diseases and has been crossed with *Lycopersicon*. (W-6.) Two accessions of *Cucurbita pepo*, P.I. 135394 (Afghanistan) and P.I. 172870 (Turkey) are highly tolerant to mosaic virus (S-9) and 10 selections of 5 eggplant introductions (P.I. 286099-108 - Turkey) out of 300 screened at Geneva have shown consistent levels of resistance to verticillium wilt and are being distributed to breeders. (NE-9.) From 500 introductions of okra, Texas AES has selected 7 as having desirable phenotypes for genetic stocks. (S-9.) A cucumber introduction, P.I. 179676 (India), is partially resistant to angular leaf spot and powdery mildew. In Wisconsin this trait was transmitted to lines SMR 15 and 18. (NC-7.)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Sowell, Grover, Jr., and G. R. Pointer. 1962. Gummy stem blight resistance of introduced watermelons. Plant Disease Reporter 46:883-885.

SWEETPOTATO CULTURE, BREEDING,
DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Acreage and per capita consumption of sweetpotatoes have declined for many years. Production and handling of the crop require much labor. Because the sweetpotato crop has not yet been adequately or successfully mechanized, sweetpotatoes are becoming increasingly a luxury item on the market. Yields per acre remain relatively low. Losses from diseases, including those caused by viruses, are high, and controls to date have not been generally applied effectively. There is need to develop new disease control measures and to breed varieties of sweetpotatoes with high disease resistance. Volume of processed sweetpotatoes is far below that of white potatoes although about one-third of the crop was processed by canning and by freezing strips and slices in 1960. Further decline in consumption per capita has been retarded by the moderate trend toward processed products for which mechanization has been somewhat successful in lowering the per-unit costs of production. There is need for the development of new and improved varieties of sweetpotatoes of high quality and suitability for processing, especially canning. Additional research is needed on the nature and control of diseases.

USDA PROGRAM

Breeding and selection to develop new sweetpotatoes possessing superior properties for fresh market and commercial processing uses have been continued at Beltsville, Md., and Meridian, Miss. Selection is based on characteristics such as appearance, shape and uniformity, external and internal colors, freedom from excessive enzymatic darkening, eating quality and processing attributes, high-yielding capacities, storability, ease of propagation, multiple disease resistance, and adaptability to mechanical handling. Workers in some 20 sweetpotato-producing States cooperate in this program. There is urgent need for fundamental studies on the genetics of this crop in order to facilitate the breeding and improvement work. To this end Federal studies have been initiated at Tifton, Ga., on the genetics and cytogenetics of the sweetpotato and related species. Development of parent breeding lines will be undertaken at this location. The breeding and selection work at the Meridian, Miss., location is being terminated and the Meridian personnel transferred to Tifton to assist with the genetic and parent line development phases of the project. Breeding and selection and coordination of the overall improvement program will continue at Beltsville, Md.

Evaluations of advanced breeding lines and selections for resistance to Fusarium wilt and black rot as well as studies of the nature and control of virus diseases, especially internal cork, are done at Beltsville. The influence of insect vectors in the spread of virus diseases is stressed in the latter work.

The Federal effort devoted to research in this area totals 4.9 professional man-years. Of this total 3.6 is devoted to breeding; 1.0 to diseases; 0.1 to variety evaluation; 0.1 to culture; and 0.1 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Seed Production in Greenhouse and Field. About 7,000 seeds resulted from the controlled crossing and additional large numbers of seeds resulting from open pollinations were collected in greenhouse and field at Beltsville, Md., and Meridian, Miss. Twenty-two of the 30 parental stocks in use at Beltsville in the 1962-63 season were used as parents because of their desirable low tendency to darken. Larger proportions of selections with low-darkening potential along with other desirable properties should be found in plants grown from seeds produced in 1962-63.

2. New 1962 Seedlings. A total of 1,582 seedlings, selected for desirable color characteristics, out of approximately 13,000 new seedlings started in 1962, were observed in field plantings at Beltsville, Md., and Meridian, Miss. Two hundred and thirty-six of these were selected at harvest. After baking-quality and storage evaluations, 72 remain for further field and laboratory evaluations in 1963.

3. Seed Maturity and Germination Studies. Preliminary germination studies were conducted on numerous lots of sweetpotato seeds stored as long as 15 years. Germination of sweetpotato seed may be less affected by age than by conditions under which seeds are harvested, dried, and germinated. Excellent germination has been obtained at Beltsville with some seed lots stored in an ordinary office file for 15 years whereas very poor results were obtained with other lots only a year or two old. Approximately 6,400 open-pollinated seeds from seed pods in varying stages of maturity, collected in the field at Beltsville in September 1962, are being used in current laboratory and greenhouse studies to determine the conditions affecting sweetpotato seed germination and seedling vigor.

4. Genetic and Cytogenetic Studies and Breeding Parent Development. In cooperation with the Georgia Agricultural Experiment Station, 60 Ipomoea species were collected at Tifton, Georgia. Preliminary chromosome counts have been made from pollen mother cells and root tip smears of I. batatas and 13 related species. Lists of sweetpotato selections, introductions and varieties of known reaction to various diseases, and possessing characters for abundant flowering, high seed setting ability and other desired characteristics, have been prepared. A limited number of these have been collected at Tifton for use in the breeding parent development work.

B. Diseases

1. Fusarium Wilt. Wilt reaction ratings were obtained for 647 seedling and introduction lots during the year, utilizing the greenhouse test-bed technique. Almost 20 percent of the selections tested were tolerant to highly resistant to the 5 wilt strains used in the tests.

The fusarium fungus, a soil inhabitant, ordinarily enters the sweetpotato plant through wounds produced on the roots, but once in a while this appears not to be the case. To check on the possibility of entry through stem wounds, greenhouse tests were made on 3 kinds of wounds (abrasion, incision, puncture) on Porto Rico stems as compared to root inoculations. It was found that stem infections were relatively unimportant. Only an occasional stem inoculation produced serious injury or death.

2. Black Rot. In the 1962-63 tests for susceptibility or resistance to black rot, 20 sweetpotato seedlings were inoculated with three different cultures of Cerotocystis fimbriata from one source in Beltsville and two in Maryland. Of the 20 seedlings tested, L-9-66, B7220, B7259, B7303, B7311 were high in resistance to the black rot disease.

3. Internal Cork. Varietal susceptibility to internal cork was studied in 47 different lots of sweetpotatoes collected from fourteen different States. The source of internal cork inoculum was diseased Porto Rico. This stock averaged 65% of its hills infected with cork lesions at the end of the experiment, while the 4 check rows of initially healthy plants averaged 29 percent. The incidence of cork in the 47 exposed varieties ranged from zero to 100 percent; 6 varieties showed 71-100 percent infected; 5 varieties 51 to 70 percent; 11 varieties 26 to 50 percent; 15 varieties 1 to 25 percent. Acadian, Australian Canner, Canbake, Earlyport, Georgia Red, Jersey Orange, Muguga, Red Nancy, Red Earlysweet, and Sunnyside were symptomless. The 7 lots of the Porto Rico variety showed percentages of symptoms ranging from 11.1 to 90.0 percent. This variation within one variety suggests somewhat that the leafspot virus component of the syndrome may interfere with root lesion expression by the internal cork virus.

4. Feathery Mottle. At Beltsville a study was made of the viral composition of the feathery mottle virus complex that occurs in the Georgia Red sweetpotato. The Georgia source of feathery mottle appears to involve a mixture of three disease-causing viruses--yellow dwarf, internal cork, and leafspot--confirming earlier findings on the Beltsville, California, and New Jersey sources.

5. Yellow Dwarf. Under field conditions it is not possible to evaluate sweetpotato varieties accurately for susceptibility to yellow dwarf virus because some varieties and selections appear to have plant characteristics that enable them to escape inoculation by the abutilon whitefly vector. One alternative is to employ graft inoculation in the greenhouse. By grafting it was possible to infect all selections tested and produce severe dwarfing of both tops and storage roots.

6. Rhizoctonia on Roots. An unusual, dry, black root condition was observed on Jersey-type sweetpotatoes during the 1962 growing season at Beltsville. This condition was later found general over the region and appeared to be associated with drouth. Of several fungi found associated with this condition, Rhizoctonia was most prevalent. Specimens of Yellow Jersey roots with a similar condition were received from Eastern Maryland in 1961. The black root condition was reproduced from this material grown in sterilized media in the greenhouse and the Rhizoctonia fungus, among others, was isolated.

7. Heat Treatment for Virus Control. Two series of 6-month heat treatments (38° C.) for the elimination of the internal cork virus syndrome from sweetpotato plants were conducted during 1962 and confirmed the results of the previous year. By the end of 6 "prunings" at monthly intervals, some mother plants yielded only virus-free cuttings, an indication that those tissues were "cured" of infection through heat inhibition of virus translocation into the new growth.

C. Variety and Selection Evaluation

1. Regional Testing of Advanced Selections. One Meridian and three Beltsville selections were among 19 advanced lines making up the replicated and observational trials conducted regionally in 1962 at 26 locations. Although B6521 and B6708 showed promise at several locations, performance of neither was sufficiently consistent throughout the region to justify continuance in the 1963 trials. Samples of the regional selections grown at Beltsville were processed and canning characteristics evaluated through cooperation of the Horticultural Crops Branch, Agricultural Marketing Service. Canned samples of 11 of the 19 selections, including B6708, were rated grade A by personnel of the Processed Foods Inspection Branch, Agricultural Marketing Service.

2. Other Selection Trials. Ninety-nine seedling lots at Beltsville and 126 at Meridian, selected prior to 1962, were further compared in replicated field trials. Of these, 52 lots have been retained for additional study. Excessive drought at Beltsville in 1962 resulted in unusually good expression of cracking tendencies and fusarium wilt susceptibilities in selections. Good opportunity was thus afforded for selection, under field conditions, of sorts with resistance to these weaknesses.

3. Enzymatic Darkening. Roots of 44 selections, including all of the Regional test lots and 21 second-year Beltsville seedlings were rated for degrees of flesh discoloration using both the catechol-oxidase and hot-water methods. Notably low darkening potentials were indicated for 7 Beltsville seedlings and 4 seedlings from elsewhere in the region.

4. Introductions. Through cooperation of the New Crops Research Branch three new sweetpotato introductions, one each from Guatemala, Mexico, and Taiwan, were obtained for study in 1962 field plantings. These were observed along with 41 previously introduced selections. Under the dry, seasonal conditions many introduced lots formed very few acceptable storage roots. The principal value of these introductions lies in their potential as gene sources of disease resistance. Selected lines are to be utilized in the parental development project at Tifton, Ga.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

Steinbauer, C. E. 1963. Condensed Progress Reports, 1962, for participating United States Department of Agriculture and State Experiment Stations. Secretary's Summary. USDA CR-87-62. p. 45. Multilithed.

Diseases

Hildebrand, E. M. 1962. Evaluation of sweetpotato breeding stocks for susceptibility to internal cork virus. *Phytopathology* 52(11):1168-1172.
Hildebrand, E. M. 1962. Viral composition of feathery mottle in Georgia Red sweetpotato. *Plant Disease Repr.* 46(11), p. 796.

ONION, CARROT, AND OTHER ROOT AND BULB CROP
CULTURE, BREEDING, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Onions, carrots, and related crops such as garlic and shallots are intensive crops involving considerable hand labor but yielding a relatively high return per acre. Production is fairly well stabilized and adapted to highly specialized areas. Cultural requirements, methods, and practices vary widely from one location to another, and present research facilities are not adequate to develop the much needed improvements in methods of growing the crop as well as producing seed for planting. Hybrids give increased yields, uniformity of product, storage quality, and overall higher production efficiency; but methods of hybrid onion seed production need further perfecting, and principles of hybrid carrot seed production need yet to be worked out. Field diseases vary in kind and intensity with the climate, soil, and other environmental factors in the various production areas, and there is need to develop better means of chemical and biological controls. Many diseases are soilborne and others are of such nature that control is feasible only through development of genetically resistant lines. Breeding lines need to be evaluated for resistance to diseases such as pink root, fusarium rot, purple blotch, mildew, and white rot to find sources of genetic resistance. Breeding needs to be done to incorporate resistance to diseases and insects into varieties suitable for home and commercial production. The generally rather narrow environmental adaptation of most varieties limits them to specific production areas, necessitating many regionally adapted varieties.

USDA PROGRAM

The United States Department of Agriculture research in this area is long term and continuing. The primary objectives of the research are to develop new and improved varieties and hybrids of carrots and of onions that are disease and insect resistant, high yielding, more uniform, and adapted for special uses. This work is being done by Federal personnel at Beltsville, Md.; Greeley, Colo.; and Parma, Idaho. The station at Parma also develops information on cytology, genetics, and problems relating to seed production. Development of breeding lines with genetic resistance to diseases is a major objective at Beltsville and is done cooperatively with many State Experiment Stations and private seed and food-processing companies. Germ plasm from species related to Allium cepa is being utilized to improve the commercial onion. Breeding of onions and carrots, including work on development and improvement of hybrids using cytoplasmic male sterility, is done

cooperatively at Madison, Wis.; Davis, Calif.; Logan, Utah; Ithaca, N.Y.; and Ames, Iowa. Studies of the nature and control of diseases of carrots are conducted at Weslaco, Tex. Research on onion diseases is being done through informal cooperation with several State and private agencies.

A contract with the Institute of Soil Science and Cultivation of Plants at Skierniewice, Poland, provides for the study of the nature and control of onion downy mildew, including a search for resistant germ plasm. The contract, arranged under P.L. 480, covers the five-year period 1962-1966, and amounts to \$31,926 in Polish zlotys.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years, divided as follows: 3.0 breeding and genetics; 0.5 diseases; and 0.1 program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Short-day onions. Lines of Allium cepa (obtained from the Plant Introduction Investigations of the New Crops Research Branch) and crosses with related Allium species are being evaluated for pink root resistance and for adaptability. Lines are being evaluated for resistance to Botrytis leaf blight. Both short-day and long-day types are in the trials. (Cooperative with Texas, California, and Louisiana Agricultural Experiment Stations)

2. Long-day onions. Cooperating in the long-day onion breeding program are the Agricultural Experiment Stations of California, Colorado, Idaho, Iowa, New York, Utah, and Wisconsin. In addition, many of the major vegetable seed companies cooperate formally and informally in the basic aspects of the improvement and disease-resistant work.

a. Species hybrids. During 1961-62, 3800 individually numbered onion plants were grown in the greenhouse and coldframes at Beltsville. About one-fourth were from crosses among 10 Allium species.

b. Cage increases. One hundred cages, size 2' x 4', were utilized to increase selected lines under isolation. Established inbreds were increased in 8 large cages, 12' x 21'.

c. Evaluation of hybrids. Experimental hybrids were tested at Greeley, Colo. It was especially noted that pink-root-resistant inbreds yielded better than susceptible inbreds.

Three-way hybrids (i.e., hybrids with constitution of $\sqrt{F_1}$ Inbred A x Inbred B x Inbred C) continued to be high in yield and uniformity. Among these were: (B 5546 x B 2108) x B 2215, (B 1900 x B 2190) x B 12115-2, (B 2264 x B 2267) x B 2215, (B 2264 x B 2267) x B 12115-2 and (B 2264 x B 2473) x B 2215.

F_1 hybrid combinations that were especially high yielding in 1962 tests were: U 16-3-11 x B 12115-2; P 52-371 x P 54-306; B 2267 x U 16-3-10-2; B 5546 x B 4332; B 2108 x Ia 2997.

Higher yields were obtained with Spanish x Spanish than with Yellow Globe x Spanish inbreds.

d. Evaluation for thrips resistance. Evaluations of onion lines for resistance to thrips, in cooperation with the Ohio Agricultural Experiment Station, were continued. Thrips-resistant lines are being increased in isolation cages at Beltsville.

e. Inbred improvement. B 2217, B 2264, B 2218, B 2228, and B 2237 were selected for slow bolting, in cooperation with the California Agricultural Experiment Station.

Pink root resistance and nondoubling are being incorporated into the two pollen parents, B 2215 C and B 12115 C. The pollen parent B 12132 had a degree of resistance to pink root, but is a poor seed producer.

The inbred B 887 derived from the F_2 of the cross B 12132 B x P 74-9-32 promises to correct some of the poor seed productivity of B 12132 and is resistant to pink root in eastern Oregon.

The inbreds U 16-3-11 and U 16-3-10-2 released jointly with Utah, and P 52-371, P 54-306 released jointly with Idaho, continued to be among the outstanding inbreds for combining with Yellow Globe and also with Sweet Spanish.

f. Brown seed coats. B 58-614 B, an inbred similar to B 2264, was increased in a large cage. All plants had brown seed coats, an important marker gene. The character appears to be controlled by one pair of homozygous-recessive genes. In addition, the inbred has resistance to pink root in Oregon and in Texas, but it is not homozygous for resistance.

g. Selection for tolerance to CIPC. Increases are being made of selections tolerant to CIPC, to develop varieties better adapted to chemical weeding. Inbreds that had some tolerant individuals are: Ia 42, Ia 55, Ia 2640, Ia 3409, B 2259, B 2473, B 5546, P 11-2, P 52-348, P 74-9, U 16-3-10-2, B 12115-2, and others.
(Cooperative with the Crops Protection Research Branch)

h. Seed yielding potentials of inbreds. Seed yields have been very low on some of the inbreds. Seed counts per plant of eight inbreds grown at Beltsville in large cages were: Oregon Yellow Danvers, 1283; B 2133, 1410; B 2207, 1710; B 15-108 B, 1527; Ia 2997 B, 486; B 2259, 1403; B 2215, 1404; and B 58-614, 854. There were also differences in the number of umbels per plant.

i. Annual work session. An annual work session on hybrid onions was held in February at the U.S. Colorado Potato Experiment Station, Greeley, Colo. Onion breeders from State Experiment Stations and seed companies from all parts of the country, met to evaluate the inbreds and new hybrids developed under the Federal program with cooperating States and agencies.

j. Genetic studies. In cooperation with the Idaho Agricultural Experiment Station estimates of heritability by regression and selection methods were continued in Yellow Sweet Spanish strains. A group of F_1 hybrids between inbreds differing in bulb shape were predominantly of shapes intermediate to the parent lines. Phenotypic correlations of some bulb measurements in this group of inbreds and hybrids suggest that bulb weight and diameter within lines are associated about equally and significantly with number and thickness of scales together, but not with scale number or scale thickness considered separately.

The elimination of annual flowering in onion by selection is expected to be slow in Idaho because the environment results in a low incidence of expression of the trait. In 1959, bolters and adjacent nonbolters were selected from a field in which the incidence of annual flowering was 2.40%. In 1962, the average incidence of annual flowering in S_1 families derived from these selections was 3.97% from annual-flowering parents and 0.17% from biennial-flowering parents. Selection and genetic analysis will continue.

Mother bulbs were grown from colchicine-treated parents identified as tetraploid and from irradiated material suspected of possessing chromosome translocations. The bulbs will require close examination when they flower at Parma, Idaho, in 1963.

k. Pollen abortion studies. Pollen abortion in hybrids of Allium cepa with A. galanthum and A. pskemense is high and few seeds are set. Mean percentage of stainable pollen was determined for species and hybrids grown at Parma, and ranged from 9% for WP 3-203-77-2 A x (A. galanthum Calif. 565) to 96% for A. pskemense Calif. 415 and PI 252051.

l. New varieties released. The following Yellow Globe-type onion varieties were named and released in 1962:

Spartan Era (Ia 736 x MSU 611) cooperative with Michigan and Iowa. Spartan Era was released as a potential replacement as a late storage variety for strains of Downings Yellow Globe, being earlier and having more uniform maturity. Because of its firm bulbs it is especially suited for mechanical harvesting, bulk storage, and pre-packaging.

Nugget (Ia 736 x W 101) cooperative with Iowa and Wisconsin. Nugget is extremely firm fleshed, with bulbs excellent for storage.

Hickory (Ia 163 x W 101) cooperative with Iowa and Wisconsin. Hickory has firm fleshy scales, golden-brown paper scales which adhere well throughout storage, and does not double readily. It is adapted for bulk-handling and bulk-storage practices.

3. Shallots

A number of shallot lines resistant to the pink root fungus, Pyrenochaeta terrestris, are being increased vegetatively in Florida and by seed in Utah and at Beltsville. Concurrently in Florida, Texas, and Louisiana, the lines are being checked for adaptability. This work is cooperative with Louisiana, Florida, and Texas Agricultural Experiment Stations.

4. Carrots

Carrot breeding work is being done cooperatively with the Agricultural Experiment Stations in California, Idaho, Michigan, New York, Texas, and Wisconsin.

a. Carrot hybrids. Although studies continue on the inheritance and utilization of male sterility in carrots, no genetic system has yet been developed to assure commercial success of hybrid carrots. More than 15 sources of male sterility have been found, but the genetics of the different forms is proving very difficult to understand.

b. Varietal description. Based upon studies made in this project, a system of mathematical description of carrot root shapes is nearing completion.

c. Genetic studies. About 30 different F_1 hybrids between varieties of varying shapes were selfed to produce F_2 's segregating for shape.

Data were collected on families segregating simultaneously for male sterility, flower color, and leaf pubescence.

Pollinations of carrot with a few Daucus species were attempted. Results are to be evaluated in 1963.

Stecklings of an X_2 generation of irradiated Waltham HiColor were grown to be screened for chromosome translocations in 1963.

Mass and individual cages of selections for and against green shoulders in a variable population were continued at Parma, Idaho.

Additions to the USDA collection in Idaho were obtained chiefly from foreign botanical gardens through cooperation of the New Crops Research Branch. Many designated as separate species appear to be probably subspecies of Daucus carota.

Seed yield of selfed carrot plants are often disappointingly low. The cause of seed failure needs to be investigated.

d. Field trials. Five hundred breeding lines were grown for evaluation in duplicate plots and 20 lines in triplicate at Salisbury, Md., in cooperation with the Maryland Agricultural Experiment Station. A number of the lines are being increased for further evaluations. True breeding lines were found variously having freedom from green shoulders, freedom from interior greening, dark, and having uniform orange color and desirable shapes for fresh market and for processing.

e. Specific gravity studies. Specific gravity of individual carrot roots differed among four commercial varieties. The average specific gravity of 100 roots ranged from 1.015 for Royal Chantenay through 1.019 for Eureka; 1.021 for Danvers 126; and 1.031 for Empress. Two of the 100 roots of Royal Chantenay, however, floated in water.

f. Seed production. About 3500 individual roots were grown in the greenhouse at Beltsville for seed production. In addition, four large lots were increased at Greeley, Colo.; one large lot at the University of Maryland Farm; and eight groups increased at Beltsville in the large cages with the onions.

5. Beets

Curly-top-resistant table beets from earlier work are being increased for observation by seedsmen and processors.

B. Diseases

1. Fusarium of onions

Work on fusarium resistance is being continued in cooperation with

the Colorado Agricultural Experiment Station. A field plot was established at the U.S. Colorado Potato Experiment Station. Seed is being produced from selected bulbs of the inbreds Ia 90, Ia 718, Ia 2578, B 2117, B 2190, B 2129, B 2473, B 2215, and others, which have shown promise for resistance to fusarium.

2. Pink root of onions

In cooperative tests with the Idaho and Oregon Agricultural Experiment Stations, inbreds found homozygous resistant to pink root were: B 887, B 2190, B 2473, Ia 13, Ia 2578, Ia 2997, Co 7-13-4, Wa 6-819, P 52-448-1-3, P 52-448-1-4, P 52-448-3-6, P 53-364, P 54-306. Another 21 inbreds showed resistance but were not homozygous for resistance. Most Sweet Spanish varieties had some resistance. These will be further selected.

Large cage increases are being made of four inbreds found to be resistant to pink root in Oregon.

Many of the interspecies crosses showed a very high level of resistance. A. fistulosum and A. porrum are practically immune to the pink root fungus. Most strains of the Red Globe are extremely susceptible.

3. Mildew resistance in onions

Selected individuals of Plant Introduction 249903, which has been screened for mildew resistance, also contained pink root resistance. So far this is the only line showing resistance to both diseases.

A field plot for mildew resistance in cooperation with the California Agricultural Experiment Station and the Ferry-Morse Seed Company was continued. New sources of resistance are being sought in this country and in Poland. Studies on the nature of onion mildew were initiated in Poland.

4. Botrytis leaf blight

The variety Burgundy appears to have resistance to Botrytis leaf blight.

5. Carrot diseases

Field testing of carrots for resistance to foliar blights was continued at Weslaco, Tex., in cooperation with the Texas Agricultural Experiment Station.

In a search for disease resistance and improved carrot types, 200

carrot lines were tested in the field during the winter season of 1961-62 in the Lower Rio Grande Valley. Eleven lots of roots found to have some field resistance to foliage blights were returned to Beltsville for further evaluation and for seed production. These disease resistance investigations include both shipping and processing types of carrots.

The Aster Yellows nursery at Greeley, Colo., failed in 1962. No readings were possible because of the low incidence of the aster hopper.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

Davis, Elmo W. 1962. Possible genetic evidence of somatic segregation in Allium cepa L. *Nature* 195: 833.

Diseases

Kehr, August E., Muriel J. O'Brien, and Elmo W. Davis. 1962. Pathogenicity of Fusarium oxysporum F. spp. cepae and its interaction with Pyrenochaeta terrestris on onions. *Euphytica* 11: 197-208.

Variety evaluation

Davis, E. W., et al. 1962. The national onion-breeding program 1961. Seventeenth Annual Report to Cooperators. Plant Industry Station, U.S.D.A. July.

PEAS AND BEAN CULTURE,
BREEDING, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The present major obstacle to economic production of beans and peas is diseases such as root rots, rust, blight, anthracnose, and curly top and other virus diseases. Aside from disease control, the greatest need of producers and consumers alike is new, more productive, widely adapted varieties having superior eating qualities and suitability for mechanized production and specific processes and uses. Biological controls of pests and diseases through breeding and other means (such as soil and crop management) are preferred to chemical methods when feasible. The details of individual problems are as diverse as the growing conditions of the nation and as the nature of the products sought. Since dry beans and peas are significant export items, breeders and producers must attend to the cooking and storing quality requirements of customers abroad. The edible cowpea or "southern pea" is becoming more popular nationally, with more extensive production and its attendant disease and adaptation problems. Bleached seed is a serious problem in dry peas. There is need to develop cultural, genetic, and pathologic information on both dry peas and lentils.

USDA PROGRAM

At Beltsville, Md., studies are conducted on breeding techniques and on the inheritance of specific economic characters, especially resistance to specific disease-causing agents of snap beans and lima beans. Outlying evaluation of breeding materials is managed from here.

At Twin Falls, Idaho, and at Prosser, Wash., applied breeding is conducted on dry beans for the West and on snap bean varieties grown both for food and seed purposes in the West. Resistance to beet curly top virus is a major objective. Breeding disease resistant peas is conducted at Prosser and on southern peas at Tifton, Ga. Emphasis on peas is on the genetics and development of disease resistant stocks for variety synthesis by others. New work is being started on the development of superior lentil and dry pea varieties at Pullman, Wash.

At East Lansing, Mich., a well rounded program of breeding and selection of disease resistant dry beans is conducted for the humid dry bean districts of the United States, chiefly Michigan and New York.

At Charleston, S.C., disease resistant snap beans are bred for adaptability to the Southeast for market and processing.

At Beltsville, Md., conventional pathologic studies on certain virus, fungus, and bacterial causes of disease and development of control measures (other than breeding) are conducted on snap and dry beans,

lima beans, and peas. Similar studies on dry beans are conducted at East Lansing, Mich., and on virus diseases of peas in the Northwest in new work at Corvallis, Oreg. New work, mainly on fungus diseases of peas, is conducted at Prosser, Wash., and diseases of southern peas at Tifton, Ga. At Prosser special attention is given to possible control of root rot of beans through microbiological means in the soil.

Research is conducted on the epidemiology of lima bean downy mildew to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1962, epidemiological research was continued in three regions, in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and University, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

A contract with the University of Sao Paulo, Brazil, provides for the evaluation of South American bean varieties for use in bean improvement. Its duration is 5 years, 1961-1965, and involves P.L. 480 funds for \$66,440 in Brazilian cruzeiros.

The Federal scientific effort devoted to research in this area totals 12.1 professional man-years. Of this number, 5.2 are devoted to breeding and genetics; 6.3 to diseases, 0.1 to variety evaluation, 0.2 to culture and 0.3 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Dry Beans

a. New releases. Two new early Red Mexican types U.I. #36 and U.I. #37 were released jointly by the Idaho Station and USDA.

b. Fusarium resistant lines. In Michigan (cooperation with the Michigan Agricultural Experiment Station) a number of white seeded types resistant to fusarium root rot were obtained by backcrossing some of the resistant types selected in 1962 to pea bean varieties.

c. Blight resistance. Plants with acceptable levels of tolerance to halo and fuscous blights were selected from a population derived from a cross between Scarlet Runner and common bean backcrossed to common bean and selfed for two generations. Further selections were made in Cranberry, Yellow Eye, and Red Kidney types with combined resistance to mosaic and anthracnose.

d. Curly top resistance. In Washington (cooperative with the Washington and Idaho Agricultural Experiment Stations) from over 100 advanced generation curly top resistant Red Kidneys, 75 selections were made and 40 bulks retained for testing and evaluation in 1963. The seed of one of the more promising mosaic and curly top resistant lines (K_2) selected at Prosser in 1959 and increased since then was found a little too small for canning although it was satisfactory in other regards. The two outstanding mosaic resistant Red Kidneys, USDA B 23 and B 25, from the 1961 Idaho tests, continued to perform satisfactorily in 1962 and it is hoped that one will soon merit release.

e. Mosaic resistance. Thirteen advanced, early maturing, mosaic- (2 strains) and curly top-resistant Red Mexican lines all showed better yielding ability than the commercial varieties. Average yields of the new lines ranged from 2,600 to 4,000 pounds per acre compared with 1,911 and 1,833 pounds for Red Mexicans U.I. 34 and 35, respectively. These early lines, over 30 selections, and 5 bulks of similar origin from our Idaho project are being evaluated for seed color and uniformity by bean dealers and brokers. The choicest lines will be increased in Washington in 1963.

f. Pinto beans. Four advanced-generation Pinto selections were compared with commercial Pintos and two yielded equal to Pinto 111. The former were shorter vined (a very desirable character) and several days to a week earlier than the commercial varieties. Further yield tests in 1963 are planned for these lines.

g. Multiple disease resistance. Out of 250 F_2 and F_3 lines from crosses, outcrosses, and backcrosses for curly top and multiple mosaic resistance in Red Mexican, Red Kidney, and Pink types, about 150 lines were retained for extended testing. From approximately 200 first backcross F_2 lines progenies of Red Mexican, Red Kidney, and Pinto with P.I. 203 for root rot resistance, 300 selections were made for further testing and additional backcrossing to desirable commercial types.

2. Snap Beans

a. New releases and superior selections. Bean line 5494-2-B, a white seeded canning type, was formally released to the trade as Harter. Approximately 17,000 pounds of seed was produced by seedsmen in 1962. A cream seeded mutant of Tendercrop, possessing all of Tendercrop's characteristics except colored seed, was selected from a planting of Tendercrop in 1961, and in 1962 approximately 60 pounds of seed was produced. This mutant will be tested in 1963 by processors in comparison with two similar ones isolated by seedsmen.

An advanced mosaic and curly top resistant shipping type (line 997), with exceptionally long slender very attractive appearing pods, is being tested in the Southern step trials and by two commercial growers in the South this season. If it performs satisfactorily, it could be ready for release by 1965.

b. Advanced breeding lines. From six advanced colored seeded mosaic and curly top resistant bush types that were tested in different sections of the country, no one was selected as the outstanding line. D 6 and 7 were chosen by the majority of the evaluators as the top lines although D 9 was considered by others as having excellent possibilities, particularly for home gardens. Since white seeded types are desired by most processors, these may be used only as home garden and fresh market sorts for the Pacific Northwest where curly top is a limiting factor in bean production; and also for hybridizing purposes. An additional 60 bulks and about 190 selections were made at Prosser and Twin Falls in similar material for critical evaluation in 1963. From 28 secondary F_{10} generation lines from both Prosser and Twin Falls, 8 bulks and 44 selections were retained at Prosser as having further potentialities. Evaluation of the top nine white seeded, round podded, mosaic and curly top resistant lines showed only one worthy of further consideration. The others had undesirable habits of growth.

From 33 advanced generation white seeded, mosaic and curly top resistant wax podded bulks and about 80 selections, only a Puregold Wax type with excellent pod color was chosen as outstanding and will be evaluated under commercial conditions in 1963. In addition, about 15 bulks and 140 selections of this material were made.

c. Rust resistance. Progress in developing rust resistant snap beans for Eastern U.S. is progressing satisfactorily. Resistant selections in F_2 and F_3 backcross and outcross material have been made and additional crosses are being made between these and several varieties including Bountiful, White Seeded Tendercrop, Gallatin #50, Harvester, Tenderwhite, and Tendercrop.

d. Curly top and root rot resistance. From a cross for root rot resistance between P.I. 203 (root rot resistant) and a curly top resistant type about 50 bush segregates in F_2 were selected. One hundred and forty F_1 lines involving root rot, curly top and mosaic resistance were increased and selections for disease resistance will be made in 1963. About 900 F_1 hybrids, backcrosses, and outcrosses were initiated in 1962 aimed primarily to produce a white seeded, mosaic, curly top, and root rot resistant snap bean type. The various crosses represent virtually all combinations of disease resistance in the major processing varieties.

e. Induction of mutations. Approximately 70 pounds of seed of the dark seeded curly top resistant lines were treated at Prosser, Wash., with a chemical mutagen, diethyl sulfate, in an attempt to induce some curly top resistant, white seeded mutants. Half of the increased seed which amounted to over 400 pounds will be planted directly in 1963 and the other half given a second treatment which might have a better chance of producing a double recessive than fresh seed since seed with one previous treatment may have hidden mutants in a heterozygous state.

3. Snap Beans for the Southeast

a. Breeding lines ready for seed increase pending introduction. Breeding line B3125-X-5-2 is being released for seed increase pending introduction as a variety. This bean has good seed quality for a white seeded type, threshes easily, and holds the attractive, uniform pods well on the plants during harvesting. The dry seed yield is excellent. The pods are very straight, round, medium to dark green in color, and very smooth. The pod set is reasonably concentrated. It is good for both processing and fresh market.

Breeding line B3370, a purple seeded home garden and fresh market type, has been highly recommended by cooperators. This line grows and yields well under adverse conditions, including soils of low fertility. In the Southern Trials B3370 had the highest average score for three years and its average yield has been significantly higher than other entries. This bean is suitable for processing where colored seed is acceptable.

b. New crosses. Crosses were made between Phaseolus vulgaris x P. coccineus to develop multiple purpose bush types. The characters of particular interest are deep green color that penetrates the entire pod, small compact cell structure with intercellular spaces greatly reduced, and thick outer wall. Most of the parent lines have various desirable flavors. These characters are being combined with disease resistant bush types that have little flavor and are considered to have only average canning quality.

c. Heritable properties of white seeded processing lines. Increased emphasis is being placed upon flavor and firmness of the pods after processing. This necessitated the use of wider crosses, including the pole type and P. coccineus. Darker green pods have been selected from these crosses. Cell diameter in these is restricted and intercellular spaces have been found to be reduced in some selections. Firmness of the canned product is associated with both thickness of the outer wall and cell size. Of the two, the latter seems more important.

In a paper chromatographic study of the chemical basis of flavor, varietal differences have been found in the flavonoids in the pods and seedlings. On the basis of Rf values and colors of spots under visible and ultraviolet light, varietal differences are evident. The flavonoids have not been identified.

d. Cooperative testing. Four of the 15 entries in the observational trials and 4 of the 8 entries in the replicated planting in the Southern Cooperative Snap Bean Trials are from this line project. A total of 624 samples were sent to cooperating agencies for observation. All samples were relatively uniform except 50 segregating lines that were supplied to the Mississippi Agricultural Experiment Station for additional selection under their environmental conditions.

4. Lima Beans

About 100 lines of baby lima beans resistant to two strains of downy mildew were further tested under field conditions. Three, lines 241, 235, and 243, which originated from a cross with Piloy (P.I. line resistant to strain B) backcrossed to Thaxter followed by five generations of selections, appear very promising.

Downy mildew resistant Fordhooks 561, 861, and 1061 continued to show promise in Maryland, New Jersey, and New York in 1962. Plants of these new lines are more compact than those of Fordhook 242 and appear to be more heat resistant than this variety. The shelled beans are slightly smaller than 242 and darker green when frozen.

Approximately 50 lines of a Florida Speckled seed type (a very popular freezing type) were selected for test in 1963.

In field plots significantly higher yields resulted from large seeds of Fordhook 242 than from small seeds.

5. Green Peas

About 100 of 540 P.I. lines planted in fusarium root rot infested soil showed some degree of tolerance. This disease is the most widespread and most frequently encountered in the Pacific Northwest.

Eleven disease resistant parent lines (from various sources) were selected on the basis of their reported resistance to 10 diseases. Resistance to as many of these will be combined into six basic processing types which are Alaska, Early Sweet, and Early Perfection (canner varieties) and the early, midseason, and late freezers. A total of about 200 F_1 combinations of 400 F_1 reciprocal crosses is planned for the winter and spring of 1962-63. The F_1 s will be planted in the field in 1963 where selection and backcrossing will be conducted.

6. Cowpeas

Over 200 varieties and accessions were grown in the field to discover sources of disease resistance. Fourteen crosses were made to study the inheritance of resistance to cladosporium leaf spot. Two sources of resistance are involved--an immune and highly resistant type found in Louisiana Purchase and Blue Goose varieties, respectively.

7. Dry Peas and Lentils

Breeding research in these two crops is just being started at Pullman, Wash. Improved disease resistant strains of Alaska, both for splits and canning (dry soakers), and yellow peas will be developed. Also, breeding for larger seeded lentils than our present sorts of both the tan and red types will be initiated.

B. Diseases

1. Beans and Lima Beans

a. Microbiological control of bean diseases. A bacterial necrosis of Fusarium by a species of Xanthomonas appears to be correlated with the severity of the bean root rot organism in soil. Beans following barley had severe root rot infection and a low necrosis of Fusaria as compared with beans following corn, sugar beets, sweetclover, and wheat which had a low incidence of root rot and a high frequency of necrosis of Fusarium.

Evidence obtained at Prosser, Wash., supported previous observations that certain preconditioning treatments of organic matter tend to stabilize its effectiveness in reducing root rot even under severe conditions. Most organic matter treatments do not kill the pathogen but merely depress its activity, and to be effective, such treatments must be accompanied by soil temperatures and other factors favorable to vigorous plant growth.

Columbia and Pinto 111 were grown in a root rot infested field in which corn was grown on one half and barley on the other half in 1961. Application of 0, 50, and 100 pounds of nitrogen per acre were also compared. Root rot incidence was about the same in barley and corn ground, but seed yields were better in the former. Root rot was more severe where nitrogen was applied; however, best yields were obtained in both corn and barley ground with 50 pounds of nitrogen per acre.

A 4-year study of the development of fusarium root rot under continuous bean cropping in newly irrigated land was completed. Previous years' results showed that root rot developed more rapidly in land where bean straw was removed each harvest than if straw was left on the land, and various broadcast applications of alfalfa meal and nitrogen reduced the incidence of root rot. Under the conditions of 1962, however, root rot was severe in all plots and not affected by any of the treatments.

b. Chemical control of soilborne diseases. SD-345 (Allylidene diacetate) (Shell) and NIA-5961 (1-chloro-2-nitropropane) (Niagra) new volatile chemicals reduced root rot more than any other chemical treatments. Under cool soil conditions they reduced stands and caused root distortions not observed in 1961 soil applications to warm soil.

c. Cultural controls. When seed was spaced one to three inches vs. six inches, root rot was less in the wider spacings. Comparing Columbia Pinto, Red Mexican U.I. 35, and Great Northern 31, root rot was decidedly less in all three varieties planted at 35 pounds per acre than in those planted at 100 or 200 pounds per acre. The disease was most severe and the yield lowest for all varieties in the 200 pound planting. Soil surface applications of alfalfa meal at rate of one ton per acre were effective in decidedly reducing incidence of infection of sclerotinia wilt whether applied to the soil and disced three inches into the soil one month before planting, immediately before planting or spread on the surface of the soil immediately prior to or after the last cultivation. The latter treatment was most effective. No increase in yield over the check resulted from the treatments, however.

d. Bean viruses. In Michigan a key for the identification of legume viruses was developed. Antisera were prepared for eight legume viruses infectious to bean for identification purposes. No serological relationship between CBMV (common bean mosaic virus) and BYMV (bean yellow mosaic virus) was found. Difficulty was experienced in obtaining a high concentration with certain viruses for preparation of antisera and in the purification procedures. Also certain isolates differed in their ability to multiply in various hosts as determined by the microprecipitin test. Standardization of this test regarding temperature and time necessary for precipitation are being studied. Studies on the longevity of eight desiccated viruses are in progress. A culture of CBMV has thus far survived 60 months.

A bean virus survey in the Pacific Northwest was continued in 1962. Commercial plantings of forage legumes have all been found to be reservoirs of many viruses infectious to bean. These include alfalfa mosaic, white clover mosaic, clover yellow mosaic, tobacco streak, tobacco ringspot, a complex of bean yellow mosaic types, a southern bean mosaic type, and others not yet identified. The percentage of seedling clover plants which have become infected the first season increased from 11% to 92.5% in experimental field plots which is indicative of the great spreading potential of legume viruses in Central Washington.

A new use of the cross protection principle, devised with inoculum produced by combining equal parts of like viruses, showed a dilution end point equal to or greater than that of the two individual viruses. Conversely, inoculum produced by combining unlike viruses half and half showed a dilution end point of about one-half that of either unlike virus alone.

Viruses infectious to bean and not previously reported seed-transmitted in any crop have been found to be seed-transmitted variously in Black Turtle bean, in red clover seed produced in the Columbia Basin, and in European tetraploid red clover seed. The predominant virus types found were bean yellow mosaic viruses but they differed markedly from the type strain of this virus. They may be related to western bean mosaic on the basis of physical properties and the above new cross protection principle.

It is generally assumed that single viruses rather than multiple types are transmitted in an individual seed. A collection of 15 BYMV types, each with a separate seedborne origin, are being compared.

Buffer types and virus concentration are being studied as factors affecting physical property determinations. The best results were obtained with 0.01 M monobasic-dibasic potassium phosphate. Dilution of crude juice inoculum with this buffer to one-tenth produced an increase of measured longevity of several virus isolates by factors of 1.4 to 2.5.

The interaction between virus infectivity and the adjusted pH of the crude juice inoculum as well as virus sensitivity to various inhibitors are being evaluated as criteria for differentiating viruses. All isolates of BYMV behave similarly to the various inhibitors but are markedly differentiated from TRSV (tobacco ringspot virus) and a southern bean mosaic virus type.

Antisera for six legume viruses have been obtained in Washington and are being used to identify naturally occurring viruses. A single positive test with Bercks' (Braunschweig, Germany) BYMV antiserum and one U.S. isolate of this virus has been obtained by the gel-diffusion technique (in Michigan this relationship was not determined). This is unusual for viruses having rod-like particles but common for viruses with sphere-like particles.

Studies on the new strain of CBMV (found serologically related to it) differing from previously described strains of the virus by its severity of infection on susceptible hosts and a more limited bean varietal range than the type strain, have been completed and the results are being written up for publication. In these studies several previously undescribed hosts of CBMV and the NY 15 virus were discovered.

In tests of P.I. lines no absolute resistance was observed for CYMV (clover yellow mosaic virus). A three-year study of relationship of time of planting to virus disease incidence and seed yield of dry bean varieties was completed. As previously noted, disease incidence was more pronounced in late May and June plantings than in mid-May.

Several new strains of BYMV from lima beans and another from beans which appear to be seedborne have been isolated. Three virus isolates from leguminous hosts (not related to beans) collected in Florida and one from cowpea, which appears somewhat similar to the severe strain of CBMV are being identified. Studies on several possible NY 15 mosaic biotypes are being conducted.

At Beltsville strains of CBMV, BYMV, and other legume viruses are being studied serologically with antisera prepared in Germany and in the United States. The antisera for both viruses reacted with the American CBMV antigen indicating a relationship between these viruses and corroborating previous German findings, but not with the BYMV antigen.

e. Root infection studies. Studies on a bean pod rot caused by an isolate of Fusarium oxysporum were continued. This isolate was found not causing root infection of beans. Isolates of F. solani are being tested to determine if this species also causes pod rot. These studies will soon be concluded.

f. Mycological studies. Progress in studies on the perfect stage of the fungus causing stem anthracnose of lima beans has been slow. Due to the failure of perithecia production because of undetermined conditions (may be due to presence of copper in the distilled water used to make the media for the growing of the fungus), the perfect stage has not yet been described. Matings, and nutritional and temperature tests as well as investigations on the presence of copper are being conducted to determine the factors responsible for this failure.

The most effective medium for growth of Phytophthora phaseoli was sterilized Golden Bantam sweet corn seeds. Of three media, frozen lima bean agar was the best for the production of the sexual stage of the fungus.

g. Bean rust. A new strain of bean rust which attacked heretofore resistant bean varieties was isolated from the Eastern Shore of Maryland. This and a previously described strain are being used in a breeding program to develop resistant varieties for Eastern United States.

h. Brown stem disease. In Idaho the causal agent of the brown stem disease of beans has been finally determined as a bacterial organism in the genus Corynebacterium. A technique has been developed to prove the pathogenicity of the organism under greenhouse conditions.

i. Downy mildew of lima bean. In the northeastern region research on methods for forecasting downy mildew (Phytophthora phaseoli) of lima bean continued. One method studied involved the calculation of downy mildew severity values from the degree of infection and extent of colonization resulting from particular combinations of temperature and 90 percent or more relative humidity for periods ranging from 10 to more than 25 hours. Limited field studies indicated that air temperatures exceeding 85° F immediately following an infection period prevented colonization.

In controlled-temperature experiments inoculated plants were subjected to treatment temperatures of 83° to 92° for single periods of 6 to 84 hours and thereafter maintained in a temperature regime of 80° to 70°. In general, colonization, as measured by length of lesions, decreased with increased temperature or increased length of exposure. Significant differences in length of leaf lesions occurred between 86° and 89°. With 24 and 36 hours exposure the length of stem lesions was significantly reduced as treatment temperature increased. Reduction in length of lesions resulting from the treatment temperatures was greater on leaves, especially with shorter exposure periods, than on stems. The treatment temperatures, however, were less effective in preventing colonization than was expected.

In the controlled environment stem and air temperatures were similar. Outdoors in sunlight stem temperatures were often as much as 7° F higher than air temperature. The hypothesis is advanced that plant temperatures in the field are sufficiently elevated above air temperatures that field results can be explained with the laboratory data.

2. Peas

a. Root rot studies. Attempts to refine techniques for studying fusarium root rot in the greenhouse, including methods of inoculation and optimum plant stages for inoculation, soil moisture, soil type and compaction as they influence disease development are being investigated.

A pathogenicity study of Fusarium solani (root rot) and F. oxysporum (wilt) types collected in 1961 and 1962 indicated that differences among isolates within species are small which probably means that it is feasible to select representative Fusarium types for varietal resistance tests.

From a high percentage of root-rotted peas, a species of Trichoderma in addition to the type Fusarium species was isolated. The Trichoderma alone produced a disease index of about 70% while the two combined produced an index of about 95%.

In Oregon a correlation was noted between the severity of virus effect on pea plants and the accompanying severity of fusarium root rot. The incidence of severely root-rotted plants was between five and six times as great in virus infected as in non-virus infected plants.

b. Virus studies. Symptom severity in Perfected Wales and Wilt Resistant Perfection peas was more pronounced when infected with a combination of AMV (alfalfa mosaic virus) and BYMV than by either virus alone. It appears on the basis of virus activity assays that these viruses have marked synergistic effects on each other. In addition to crimson clover (reported in 1961 as an overwintering host for PEMV (pea enation mosaic virus)) hairy vetch has recently been shown to exhibit strong symptoms of this virus in the field and up to 50% of these two species in an orchard ground cover stand were infected. AMV was isolated from pea plants with stem streak symptoms indicating that it may be a part of the pea streak complex found in southern Idaho.

Some Perfection type peas (resistant to BYMV) have recently been found susceptible to certain new isolates of this virus.

In Oregon antisera of three legume and of other viruses were produced in 1962. Intravenous, adjuvant or a combination of the two types of injection were all equally efficient in producing antibodies. An attempt to produce an antiserum for PEMV with crude juice extracts failed. Attempts to purify BYMV have been only partially successful and failed with PEMV.

The "dip" technique of Brandes of Braunschweig, Germany (dipping the cut surface of a virus infected leaf in a droplet of water on a grid dried and shadowed) has proved a simple and useful method for making virus particle electron microscopic pictures and measurements without the disruptive chemical and physical forces of virus purification.

Electron microscopic pictures of the particles of the New Jersey pea streak virus from Alaska (1962 report) and an antiserum of the virus were prepared. All investigations of this new disease have been completed.

3. Cowpeas

Disease surveys in 1962 showed that virus diseases were most commonly observed. In Georgia strains of southern bean mosaic, cucumber mosaic, and bean yellow mosaic were identified. Other diseases noted were scab, powdery mildew, fusarium wilt, southern stem rot, Rhizoctonia, and several others.

Three races of fusarium wilt not previously reported from Georgia were isolated from diseased plants. Race 2 was the most prevalent.

It was determined that cowpea seedlings can be rapidly screened for cladosporium spot resistance under controlled greenhouse conditions. Ratings on the resistance of 35 varieties and breeding lines agreed with their reaction under field conditions. Results suggested that resistance is inherited in a complex manner.

C. Culture

1. Lima Beans

a. Physiological studies. Thaxter lima bean seed treated with growth retardants Amo 1618, Phosfon, and Cycocel produced short, stocky plants by causing a shortening of the internodes and racemes without reducing yield.

D. Variety Evaluation

1. Brazilian Bean Collection

A collection of native South American bean varieties is being made in Brazil. These varieties will be evaluated for use in the U.S. bean improvement program.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Diseases

- Anderson, Axel L. and Don M. Huber. 1962. Bacterial necrosis and isolation frequency of rhizoctonia and rhizospheres under several cropping sequences. *Phytopathology* 52:721.
- Burke, D. W. 1962. Preconditioning and placement of organic materials in control of bean root rot. (Abstract). *Phytopathology* 52:727.
- Burke, D. W. and R. O. Hampton. 1962. Complementary effects of related viruses mixed in serial dilutions. (Abstract). *Phytopathology* 52:726.
- Ford, R. E. and M. J. Silbernagel. 1962. Downy mildew of peas prevalent in Pacific Northwest in 1962. *Plant Disease Reporter* 46:784.
- Goth, R. W. 1962. Aphid transmission of white clover mosaic virus. *Phytopathology* 52:1128.
- Goth, R. W. and R. E. Wester. 1963. Culture of Phytophthora phaseoli on living and sterilized media. *Phytopathology* 53:233-234.
- Goth, R. W. and R. D. Wilcoxson. 1962. Effect of bean yellow mosaic on survival and flower formation in red clover. *Crop Science* 2:426-429.
- Huber, Don. M. and Axel L. Anderson. 1962. Interrelation of bacterial necrosis of fusarium to crop rotation, isolation frequency and bean root rot. *Phytopathology* 52:737.

- Hyre, R. A. 1962. Colonization of lima bean plants by Phytophthora phaseoli as affected by temperature and age of plants. (Abstract). Phytopathology 52:1219.
- Hyre, R. A., John MacLeod, and Spencer H. Davis, Jr. 1962. Forecasting downy mildew of lima bean in Cape May County, New Jersey. Plant Disease Reporter 46:393-395.
- Toler, R. W. 1962. Soil-borne oat mosaic virus. Diss. Abstract 22:11.
- Toler, R. W. 1962. Cowpea scab hits crops in Southeast. Crops and Soils 15:24.
- Toler, R. W. and T. T. Hebert. 1963. Reaction of oat varieties, avena species, and other plants to artificial inoculation with the soil-borne oat mosaic virus. Plant Disease Repr. 47:58-62.
- Wester, R. E., C. Drechsler, and R. W. Goth. 1962. Viability of the downy mildew fungus of lima beans. (Abstract). Phytopathology 52:1222.
- Wester, R. E. and Tejpal S. Gill. 1962. The spread of lima downy mildew (Phytophthora phaseoli) strain "B" in New Jersey. Plant Disease Repr. 46:617.
- Zaumeyer, W. J. and R. W. Goth. 1962. New types of primary necrotic lesions produced by common bean mosaic virus. (Abstract). Phytopathology 52:1222.
- Zaumeyer, W. J. and R. W. Goth. 1962. A new strain of common bean mosaic virus. (Abstract). Phytopathology 52:752.
- Zaumeyer, W. J. and R. W. Goth. 1963. Red clover necrosis virus, the cause of streak of peas. Plant Disease Repr. 47:10-14.
- Zaumeyer, W. J. and H. Rex Thomas. 1962. Bean Diseases - How to control them. Agriculture Handbook No. 225, ARS, USDA. Formerly FB 1692. (Revised).
- Zaumeyer, W. J. 1962. Pea Diseases. Agriculture Handbook No. 228, ARS, USDA. Formerly FB 1735. (Revised).

Culture

- Wester, R. E. 1963. Plastic hoods let plants laugh at frost. Horticulture XLI:31. Jan. 1963.
- Wester, R. E. and M. C. Hetz. 1962. Current publications and commercial sources of plastic films for greenhouses, hotbeds, row covers, and mulch. CA-34-79-62. 15 pp. (Processed).

TOMATO, PEPPER, AND RELATED CROP CULTURE,
BREEDING AND GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. High costs of harvesting by hand are forcing a revolution in methods of growing and harvesting tomatoes by machine and in types and properties of tomatoes adaptable to such methods, especially for processing. Thus, the tomato breeder has additional difficult objectives to meet, regarding growth and fruiting habits, fruit properties, and propagating characteristics. The old problems of improving yield, developing resistance to a multiplicity of diseases, including curly top, and improved fruit quality for fresh use and processing are still with us. There are new pressures from large processors to conduct basic work as a basis for improving numbers and quality of plants from southern plant beds, and reducing their cost, for shipment northward. Bacterial spot is an increasingly frequent cause of trouble. Losses from verticillium wilt and "southern blight" are less tolerable than in the past. The consuming public is becoming more dissatisfied with the poor quality of tomatoes harvested green-mature. Firmer fruits are needed that can be harvested riper than is feasible with present varieties for distant markets. Seed dormancy may interfere with stands.

Disease and productivity problems of peppers are similar to those of tomatoes but the quality problems at present are generally less troublesome.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known principles to growers' problems. Tomato breeding and genetic studies at Beltsville, Maryland, involve crossing progeny selection, disease evaluation, and horticultural selection for mechanized harvesting and superior quality. At Charleston, South Carolina, breeding for adaptability to southeastern conditions is stressed; while at Logan, Utah, the prime purpose is development of genetic resistance to the curly top disease. At Woodward, Oklahoma, and Cheyenne, Wyoming, breeding is directed toward adaptability to the temperature extremes and low humidity of the Great Plains. Disease studies on early blight, bacterial spot, gray leaf spot, fusarium wilt, verticillium wilt, and tobacco mosaic virus are conducted in controlled laboratory and field experiments at Beltsville. Disease research at Tifton, Georgia, includes bacterial spot, early blight, gray leaf spot, and southern blight of tomato, pepper, and similar vegetable transplants. At Prosser, Washington, work is concentrated upon identities and variation in strains of the curly top virus. A minor amount of varietal

evaluation is conducted at Beltsville, Maryland; Tifton, Georgia; Logan, Utah; and Prosser, Washington. Work on culture and nutrition of tomato and pepper plants is conducted at Tifton, Georgia.

Research is conducted on the epidemiology of tomato late blight to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1962 epidemiological research was continued in three regions, in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and University Park, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

The Federal scientific effort devoted to research in this area totals 8.4 professional man-years. Of this number 3.3 are devoted to breeding; 3.9 to diseases; 0.3 to variety evaluation; 0.7 to culture; and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Tomato Breeding in the East. The major purpose of this work at Beltsville, Md., is to develop tomato lines and varieties for specific purposes that are adapted to the Central, Middle Atlantic, and the Northeastern States having resistance to fusarium wilt, verticillium wilt, tobacco mosaic virus and certain foliage diseases.

a. Variety Release. The Porte variety of tomato was released. It is from a cross between Beltsville breeding line U.S. 558 and breeding line Utah T 1-1 developed by the USDA in cooperation with Utah. It appears superior for fresh market production in Maryland and New Jersey, and is highly resistant to both verticillium and fusarium wilts.

b. Breeding for Multiple Disease Resistance. During 1962, at Beltsville, Md., yield trials of 64 advanced tomato lines resistant to fusarium and verticillium wilt and two foliage diseases demonstrated greater yielding ability and fruit quality than varieties recommended locally. Observational trials of 52 of these lines in southern New Jersey indicated 4 of them to be potential processing types and 2 possibly adapted for fresh market production.

c. Observational Trials. The four determinate verticillium and fusarium wilt resistant tomato lines entered in the Southern Tomato Exchange Program trials in 1962 were rated acceptable in adaptability and fruit quality at several locations. Two lines were requested

for repeat observational trials and one was advanced to the regional yield trials. Two of these lines were rated superior in fruit production in plant spacing trials in Nebraska in 1962. One line is being grown on a large scale for tests to determine adaptability to machine harvesting. An additional 23 determinate disease resistant lines are being planted in the Nebraska preliminary yield trials.

d. Genetic Studies. The close linkage of the seedling virescence recessive gene and the tobacco mosaic virus (TMV) resistance gene in tomato has been broken in a number of breeding lines. Three of these show adaptability to greenhouse production. Progeny tests are underway to assay resistance to TMV in 43 lines that are highly productive, wilt resistant and possess resistance to certain foliage diseases.

e. Nature of Resistance to TMV. Studies on the nature of resistance to TMV in tomato indicate that resistant lines are resistant to virus multiplication and translocation. Virus cannot be detected by subinoculation in inoculated plants until after the sixth or eighth flower cluster has set fruit. Warm growing temperatures may shorten this period as much as 3 weeks.

f. Breeding Paste Types. Approximately 80 paste-type selections were made from early generation progenies possessing resistance to verticillium and fusarium wilt. One of these is being grown in cooperative grower trials in Colorado. Resistance to fruit cracking and excellent fruit color in this line make it attractive for blending to improve quality of processed products of locally adapted varieties.

2. Breeding Tomatoes for the Central Great Plains. At Cheyenne, Wyo., in cooperation with the Wyoming Agricultural Experiment Station, thirty-four hybrid tomato lines and varieties and six paste lines were planted in replicated tests at Ft. Lupton, Colo. The season was favorable, and selections were made. Yields were taken for three pickings before the freeze of September 8, 1962.

Three hundred and eighty-five hybrid lines and varieties, including 90 lines from Beltsville, were set in the field at Cheyenne. A hailstorm on July 1 and a cool, wet summer hindered growth and ripening. A freeze (20°F) on September 8 killed all tomatoes at the Cheyenne station; however, a number of early selections were made.

One hundred and fifty F_1 crosses were made in the spring 1962 greenhouse crop. Seventy-four of these were crossed with disease resistant lines from Beltsville. All F_1 crosses were set in the field planting at Cheyenne and in the summer greenhouse crop to assure F_2 seed.

All F_2 lines involving disease resistant crosses and check varieties were inoculated with fusarium and verticillium wilt cultures in November. Progeny of the survivors of 68 lines were grown in the greenhouse 1962-63 to furnish F_3 seed for field trials in 1963.

3. Tomato Curly Top, Fusarium and Verticillium Resistance in the West.

The primary objective of the curly top program is control of curly top in tomato through the development of resistant varieties having high yield and quality. This work, in cooperation with the Utah Agricultural Experiment Station, Logan, Utah, and Washington Agricultural Experiment Station, Prosser, Wash., includes disease evaluation of tomato seedlings in the greenhouse and field, basic studies on the curly top virus, nature of resistance, and inheritance of resistance in the tomato.

a. Sources of Resistance to Curly Top Virus. Extensive efforts to find or induce worthwhile levels of curly top resistance in cultivated varieties of Lycopersicon esculentum have not been successful. Resistance was earlier found in wild species of Lycopersicon collected in South America. Although many genetic barriers have been encountered, all of the wild species have been crossed with L. esculentum and breeding lines are now available which have moderate to high levels of curly top resistance. In severe 1962 greenhouse seedling tests where all the plants of susceptible check lines were eliminated and only 2 to 4 percent of the plants of a "curly top resistant" variety such as Owyhee survived, 30 to 45 percent of certain advanced breeding lines remained healthy. In field tests in which only 5 percent of the susceptible check plants and 50 to 65 percent of the Owyhee plants remained healthy, from 80 to 92 percent of the plants of these lines remained healthy.

Very high levels of curly top resistance have been produced in wild, early-generation breeding material. By intercrossing, we have been able to develop lines which have combined in their pedigrees all of the species of Lycopersicon. In a very severe greenhouse seedling test conducted in 1962, several derivatives of this intercrossed material remained 90 to 100 percent healthy when our best resistant check, line 193, was 95 percent infected.

b. Selection for Verticillium and Curly Top Resistance. About 2,200 plants of 120 of these multi-resistant lines were evaluated for resistance to verticillium wilt in greenhouse seedling tests and 1,116 survivors were taken to the field at Penrose and Farmington, Utah. Seed was saved from 54 plants of 21 lines having worthwhile resistance in concurrent curly top tests. Progeny of these selections are being tested for homozygosity for verticillium resistance in greenhouse seedling tests.

Some 270 F_1 progeny from backcrosses of curly top resistant lines to commercial types were grown at North Logan and general notes were taken on plant habit and fruit quality. Seed was saved from 120 of these F_1 progeny, to be used in field and greenhouse curly top tests in 1963.

Resistance to verticillium wilt was found in a wild *L. esculentum*, Peru Wild, and backcrossed into commercial varieties along with fusarium resistance. Good verticillium-fusarium wilt-resistant lines derived from this program are crossed with the best curly top resistant lines to obtain multi-resistant lines with good horticultural type. Preliminary performance trials were conducted on 170 such lines at Farmington, Utah, in 1962. Detailed notes were taken on plant type and fruit quality and yield data were collected on 111 of the best lines. Based on their performance in this trial and concurrent curly top trials, 17 of the lines were selected for further testing in 1963.

c. Building Resistance to Curly Top. Some 25,000 seedlings of 480 lines were tested for curly top resistance in severe greenhouse seedling tests during the summer of 1962. About 900 plants were saved from the most resistant lines and selfed, backcrossed, and/or intercrossed.

Intercrossing moderately-resistant breeding lines has produced lines with high levels of curly top resistance. In one greenhouse test in which a highly-resistant three-way cross derivative and the component lines which went to make it up were tested for curly top resistance, only 8 to 23 percent of the plants of the 3 component lines remained healthy while 39 percent of the plants (almost twice the best component line) remained healthy in the three-way cross. In comparable field tests, 26 to 64 percent of the plants in the three component lines remained healthy while 94 percent of the plants in the three-way cross remained healthy.

d. Penrose, Utah and Prosser Field Trials. New curly top trial grounds were established at Penrose, Utah, in cooperation with Utah Agricultural Experiment Station, and at Prosser, Wash., in cooperation with the Washington Agricultural Experiment Station. Some 15,500 plants of 490 curly top resistant breeding lines were tested in replicated tests at these two locations. The incidence of curly top was low at both locations in 1962, but a late planting gave a fair measure of relative resistance. Seed was saved from 266 plants of 93 lines that had expressed only 0 to 30 percent curly top in a late planting. Progeny of 66 of these selections were tested in the greenhouse in the fall and plant selections made from the most resistant 12 lines. These plants are being selfed, backcrossed, and intercrossed.

An early planting (May 14) at Prosser had only 24 percent curly top in the susceptible checks and one at Penrose (June 8 to 14) had only 14 percent curly top in its susceptible checks. Based on horticultural appearance, 465 plants were selected from 208 lines which were highly resistant in the late Prosser planting and greenhouse seedling tests. In fall greenhouse seedling tests, selections were made of the 19 most resistant of the 40 tested progeny. These plants are being selfed, backcrossed, and intercrossed.

Included at Penrose and Prosser were 48 F_1 progeny lines derived from crosses between curly top resistant lines and commercial varieties. At Prosser only 8 percent of the plants in a susceptible check remained healthy in comparison to 50 to 90 percent in 12 F_1 hybrids. Four of these 12 resistant F_1 hybrids were considered to be of commercial type.

e. Regional Trials. Seed of 18 curly top resistant lines was sent to cooperators in California, Arizona, New Mexico, and Colorado for 1962 field curly top trials. The incidence of curly top was very low in all areas except western Colorado, where 55 percent of the plants in the susceptible check became infected in comparison to 0 to 10 percent in resistant lines.

A wilt-resistant line, VF 122, performed well in small trials in New Mexico and Arizona for the third year in succession. It apparently has the ability to produce a good yield of high quality fruit under the hot summer conditions of those areas. This line will be tested more extensively in 1963 and foundation seed will be increased for possible release in 1964.

f. Curly Top Testing Techniques and Virus Strain Evaluation, Prosser, Washington. Tests to determine the best ratio of virus infected sugar beets as a source of curly top inoculum and tomato plants under test indicated that one row of beets to three rows of tomatoes gave a satisfactory high percent virus infection in tomatoes.

4. Tomato Breeding for the Southeast.

a. Resistance to Leafmold. Rains starting about June 1 inhibited late fruit set and promoted extensive development of leafmold (Cladosporium) at the Charleston, S.C. Laboratory. Yields were cut far below those of the previous year. This is the fourth year out of 24 at the Laboratory in which leafmold has been quite severe on field tomatoes and our belief that leafmold resistance would be an important asset commercially in the Southeast remains firm. Many of our present breeding lines carry a good level of resistance.

b. Inbreeding Depression. Eighteen lines that had been continuously selfed for at least 4 generations were compared in respect to seed vitality with eleven related lines that had been sib-pollinated for at least the immediately preceding generation. One hundred seed of each were germinated in the same flat and the seedlings classified for vitality. The fast-germinating class was represented by 65 percent of the selfed seedlings and 82 percent of the sib-cross seedlings; conversely, the slow-germinating class included 35 percent of the selfed seedlings and only 18 percent of those from sib crosses. Total percent germination was the same for the selfed and sib-cross groups. Perhaps continuous selfing of tomatoes does have a depressing effect which is expressed only, or primarily, in seedling vitality; continued sampling of the kind indicated may prove the point one way or the other.

c. Genetic Variance. Commercial stock seed of Marglobe and Rutgers, both aged 8 years, were planted in sufficient quantity to give 1,000 seedlings. Seedlings were selected for diversity of 2 generations with a relatively small number grown to maturity in each. We now have populations of both varieties which show surprising lack of homogeneity, including some very distinctive plant types and several male steriles. It seems possible that mutations accumulating during the relatively long seed storage could account for the heterogeneity, but also it is possible that a substantial amount of heterozygosity may have persisted in these commercial stocks through some unidentified genetic mechanism.

d. Alternation of Self- and Sib-pollination. Twenty-nine breeding stocks were grown in the greenhouse in the fall of systematic sib-crossing; each generation of sib-crosses to be alternated with natural selfing in the field the following spring. Sibs for crossing are selected in the field by an index system. Some items in this series are now in the fifth generation, all will be carried through at least the eighth. End products will be compared with continuously selfed lines from the same original parentage. Some of these breeding stocks had been previously inbred for many generations, others started as hybrids in F_2 ; also included is the original breeders stock of Homestead.

B. Diseases

1. Tomatoes and Peppers

a. Tifton, Georgia. Occurrence of the bacterial spot disease in tomato and pepper plant beds was rare in 1962. Distribution of the few infected plants that were observed suggested that the bacteria were seedborne.

At Tifton, Ga., in cooperation with Georgia Agricultural Experiment Station nitrogen sources and rates of application were varied to study the effect of these treatments on susceptibility of tomato plants to southern blight (Sclerotium rolfsii). Conditions were highly favorable for disease occurrence. The results were inconclusive.

b. Logan, Utah. The identity of an apparently seedborne virus which causes severe defoliation of infected plants is under study.

c. Prosser, Washington. A virus highly infectious to pepper has been isolated from the Wapato area of the Yakima Valley and its identity is under study.

At Prosser, isolates of the curly top virus have been obtained from the various tomato growing areas of the West to study differences among the virus strains in relation to resistance in the tomato. These studies are in progress.

d. Beltsville, Maryland. Investigations were initiated to determine the capacity of some chemicals to disinfest germinating tomato (Rutgers) seeds in water solution. Seeds infested with Xanthomonas vesicatoria were germinated in solutions containing various concentrations and types of antibiotics, fungicides and disinfectants. Hexachlorophene and its sodium salt completely disinfested the seed and emerging seedlings of the bacterial spot organism. Further tests are planned to determine the efficacy of these and other chemicals against post-emergence and pre-emergence damping-off fungi using the technique of germinating seeds in solution.

Tests indicate that indoleacetic acid, when applied to foliage of pepper plants, may be instrumental in decreasing both the incidence and severity of bacterial spot, as well as decreasing the amount of leaf abscission. In vitro tests show the IAA incorporated into culture media at concentrations of 10^{-4} , 10^{-5} exerts an inhibiting effect on growth of the bacteria. Further work is planned to determine the interrelationship between the pathogen and disease manifestation exploring the role of auxin (time and rate of application) and nitrogen metabolism in the disease process.

e. Late Blight of Tomato and Potato. In the north central region investigations on conditions responsible for outbreaks of potato late blight (Phytophthora infestans) were continued. Development of late blight from inoculated seed pieces was watched in unsprayed "late blight gardens" at Ames, Boone, and Clear Lake, Iowa. Fewer sprouts were produced by inoculated than by uninoculated Cobbler and Red Pontiac seed pieces at Ames and Red Pontiac seed pieces at Boone; the reduction in emergence was especially severe in the heavier black mineral soil at Boone, where only 57 percent of inoculated as compared

with 98 percent of uninoculated seed pieces produced sprouts. Some primary blight lesions appeared on sprouts at Ames and Boone but disappeared without secondary spread after the middle of June. Meteorological data indicated that during the period of rapid lesion growth temperature and moisture were unfavorable for sporulation and reinfection. With the advent of more favorable weather there were no young lesions to resume development. The foliage was relatively open and the small plants afforded the fungus relatively little protection from sunshine and air circulation during a 14-day period with temperature maxima over 80° F. No blight symptoms were observed on emerging sprouts or mature plants at Clear Lake although temperature and moisture conditions there would have favored aerial development; perhaps, a late planting date and rapid emergence in warm soil prevented the fungus from invading the growing sprouts.

During June, July and August dew records taken visually and with three different dew recorders were compared with each other and with relative humidity data recorded by a hygrothermograph in the same plot. For the visual dew observations the leaves of a number of potato plants were closely examined with the aid of a flashlight and a hand lens. Dew "burn-off" was recorded at the time the upper leaves dried off. Some of the lower leaves on the older plants were wet all day and dried off only if the relative humidity was low or a breeze was blowing. The time of "burn-off" from the upper leaves most closely approximated that recorded by dew recorders. The field studies revealed that all instruments were useful in identifying dew periods; that the lamb-gut sensor type was slightly more sensitive than other recorders in identifying time and duration of dew deposition; that 90 percent relative humidity periods were generally longer than dew periods recorded by any of the dew recording instruments; that dew was usually recorded by the lamb-gut recorder 18 minutes after dew appeared on the foliage; that dew appeared on the foliage about 30 minutes before the relative humidity reached 90 percent in the louvered hygrothermograph shelter; that dew generally "burned-off" the foliage 5 minutes after the relative humidity dropped below 90 percent; and that dew "burn-off" the foliage 57 minutes earlier than from the Taylor glass plate dew recorder.

The United States Weather Bureau again furnished records of the number of consecutive hours of temperature-dew point spread of 3° at 90 percent relative humidity for ten first-order weather stations for the period June 18 - September 15. In addition, the Bureau provided weekly synoptic weather reports translated into possible indications of late blight conditions for the region. The information was most useful in augmenting data for the weekly late blight predictions. The Bureau will continue to supply the late blight regional weather data.

Experimental blight forecasts were issued from 23 weather-blight forecast stations in the North Central States. Reports indicated that the forecasts were accurate in most States; information from others is lacking or insufficient to judge accuracy.

In the southeastern region late blight forecasts were made for commercial potato-growing areas around Charleston, South Carolina, and Aurora (Eastern Shore), North Carolina. In both locations weather from the beginning of April until the end of May did not favor the development of late blight. Between the end of May and the time of harvest, conditions were very favorable for sporulation and spread, but apparently the earlier unfavorable period had prevented establishment of the fungus since the disease was not reported except in some irrigated fields in North Carolina. Its presence in the irrigated fields, where it was found on June 8, showed that the fungus could become established in such fields and persist undetected until weather favored secondary spread. All original infection centers appeared in rows adjacent to main water carrying ditches where the soil was continuously moist. 1962 was the third consecutive year that late blight was not reported on tomato plants in the Eastern Shore of South Carolina.

In the northeastern region research on late blight forecast methods was continued. In a "late blight garden" at Penn State University only 6 plants emerged from 118 inoculated Katahdin seed potato tubers incubated at 70° to 60° F for 12 hours on each of 8 days before being planted in dry soil. The fungus was found on a sprout that failed to emerge, but no blight developed on the 6 plants that came up. The season was dry and no blight occurred elsewhere in the vicinity.

Field blight stations were established in four commercial potato-growing areas in Pennsylvania, in York, Lehigh, Potter, and Erie Counties, for comparison of forecast methods. Methods based on temperature and 90 percent relative humidity records and on temperature and rainfall data were equally satisfactory for predicting occurrence of late blight under the varying conditions of these commercial areas. Certain restrictions should be noted: for the temperature - 90 percent relative humidity method, an infection period should be disallowed if the maximum temperature on the following day exceeds 85° F; for the temperature - rainfall method, blight-favorable periods (especially minimal ones) early in the season when the plants are small should be disallowed.

Regional late blight forecasts for the northeastern region were discontinued in 1962, in accordance with the goal of the forecast research program, understood as the development and verification of forecast procedures for eventual utilization by other agencies. The regional pathologist initiated programs leading to assumption of local responsibility for the forecasts as early as 1960 in some parts of the region. In the various areas different methods of handling forecasts have been adopted, notably in Maine and New Brunswick where a cooperative program was set up, and in New Jersey where a newly appointed Advisory Agricultural Meteorologist took over the forecasts.

f. Bacterial Spot of Pepper and Tomato. In the southeastern region investigations on the epidemiology of bacterial spot of pepper and tomato were started in 1962. In a field experiment in North Carolina pepper plants were inoculated with a virulent culture of Xanthomonas vesicatoria. Only slight infection and very little spread resulted. Weather records taken in the experimental plot showed a total precipitation after inoculation sufficient for normal plant growth. Rainfall occurred mostly as daytime showers, however, and the plants dried off before night. Apparently this rainfall regime was not conducive to infection and spread.

Pepper transplants grown in southern States often constitute a source of inoculum for northern pepper-producing areas. In 1962, however, transplants were practically free from bacterial spot. Records from weather stations set up in three transplant fields in the Tifton, Georgia, area showed unusually dry weather from April 1, when the seedlings had just emerged, until the end of May, when the plant shipping season ended. No bacterial spot was observed in these three fields.

Observations in Georgia transplant fields throughout the season showed a trace of infection by May 14, but secondary spread was negligible even though all fields were irrigated.

Isolates of the bacterial spot organism, Xanthomonas vesicatoria, of tomato and pepper obtained from Indiana, Florida, Delaware, and Israel, and 35 isolates of X. vesicatoria made from diseased pepper leaves from different parts of North Carolina were pathogenic to both tomato and pepper in greenhouse inoculation tests. No differences in virulence were noted.

Diseased pepper leaves also yielded additional isolates that produced various types of yellow bacterial colonies. Twenty-three yellow isolates tested in the greenhouse were nonpathogenic to pepper and tomato seedlings.

Pepper seedlings showing symptoms of a bacterial leaf spot were received from Sampson County, North Carolina, on April 20. Repeated isolations yielded no colonies typical of or resembling the light lemon yellow colonies described for X. vesicatoria. Instead grayish white colonies predominated in dilution plate isolations on potato dextrose agar. On April 27 when the affected bed was visited 80 to 85 percent of the California Wonder pepper plants in a 30-sash bed were heavily infected with bacterial leaf spot. Freshly collected material again yielded only the grayish white colonies, tentatively assigned to Pseudomonas sp. So far as known, in published accounts only X. vesicatoria has hitherto been reported as the cause of pepper bacterial leaf spot.

Results of greenhouse inoculation tests divided isolates of Pseudomonas into two groups. One group was pathogenic, the other was nonpathogenic, to both tomato and pepper. The two groups differed in colony appearance as well as in pathogenicity.

Pepper plants in a field test in North Carolina were inoculated with two isolates of the tentatively identified Pseudomonas sp. Resultant infection was very light, and secondary spread was less than for the X. vesicatoria field test. Nevertheless the organism was able to maintain itself until the test was discontinued in the middle of August, as shown by reisolation from old leaf spots.

C. Culture

1. Tomato and Pepper Transplants. Studies are in progress at Tifton, Ga., in cooperation with the Georgia Agricultural Experiment Station to determine the optimum nutrient levels of N, P, K and minor elements for maximum production per acre of No. 1 tomato and pepper transplants. These studies are being conducted on newly cleared, as well as old land. Studies have also been initiated to determine the effect of the crop rotation system upon the maximum number of disease free transplants obtainable per acre.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

- Martin, M.W. 1962. Solanum pennellii, a possible source of tomato curly top resistance. *Phytopathology* 52:1230-1231.
- Martin, M.W. 1963. Comparative responses of two curly top resistant tomato lines as affected by area in which tested. *Plant Disease Repr.* 47:119-120.
- Martin, M.W. 1963. Responses of curly top resistant Lycopersicon species to curly top exposure in different areas of the west. *Plant Disease Repr.* 47:121-125.

Diseases

- Wallin, Jack R. 1962. Summary of recent progress in predicting late blight epidemics in United States and Canada. *American Potato Journal*, 39:306-312.
- Webb, R.E. and W.S. Porte. 1962. Colytedonary inoculation, a method for screening tomatoes for resistance to the tobacco mosaic virus. (Abstract). *Phytopathology* 52:486.
- Webb, R.E. 1963. Tomato curly top in Maryland. *Plant Disease Repr.* 47:53.
- Webb, R. E. and G. Libman. 1963. An epidemic of verticillium wilt in tomato in the metropolitan area of Washington, D.C. in 1962. *Plant Disease Repr.* 47:81-82.

LEAFY AND MISCELLANEOUS VEGETABLES

Crops Research Division, ARS

Problem. Major problems among leafy vegetables involve chiefly lettuce, spinach, cabbage, and those members of the cabbage family such as broccoli and various "greens" that have become newly important with the advent of quick-freezing. Our principal lettuce strains are productive but of poor quality. They are less adapted to vacuum cooling and "dry" shipment than to former iced packages. Varieties are desired that will tolerate the cheaper vacuum cooling and "dry" shipment. Seedborne lettuce mosaic, brown rib, big vein, and mildew are only partly solved or quite unsolved. The extremely "unstable" (variable) behavior of several members of the cabbage family interfere seriously with their economical production and use for processing. Substantial genetic work is needed to develop ways to "stabilize" varieties of broccoli and brussels sprouts for different regions. Inheritance of flavor and other qualities needs to be determined in order to improve acceptability for both market and processing. Further work is needed on development of F₁ hybrids as an approach to superior quality, uniformity, and yield of several of these crops. New breeding principles must be developed to improve range of adaptability and dependability of varietal performance in mechanized production and processing.

Most sweet corns grown in the South have been developed elsewhere for other conditions, and are not well enough adapted to the South. Corn earworm and *Helminthosporium* leaf blight are serious, necessitating expensive control measures. Productivity and attractiveness have generally been obtained at some expense to eating quality. Insect- and disease-resistant varieties and hybrids that are better adapted to the South and that produce and retain superior eating properties are badly needed. The desired properties must be sought out and ways developed for methodically incorporating them into commercially suitable types. Basic knowledge on the inheritance of economic characters is needed to attain these ends.

USDA PROGRAM

The Department has a continuing long-term program involving services of geneticists, plant pathologists, and horticulturists in both basic and applied research. At Beltsville, Md., spinach breeding is done for developing resistance to blue mold, white rust, and mosaic. Studies of flowering habit are conducted as a basis for best ways to produce F₁ hybrid seed. Inbreds and hybrids are developed and evaluated for disease resistance and horticultural characters, and seed is sent to various regions for further field and processing evaluation. Work on lettuce is conducted at La Jolla, Brawley, and Salinas, Calif. Professional personnel at La Jolla conduct a major

part of their field work at Brawley to develop lettuces adapted to the irrigated valleys of the Southwest. The work at Salinas is designed to serve all other parts of the country, and basic studies in population genetics are also in progress there. Resistance to mosaic and big vein, and to brown rib, tipburn, and other physiological disorders in lettuce is sought including those resulting from current methods of harvesting, cooling, and shipping lettuce. Mildew resistance is being incorporated into commercial types. La Jolla personnel cooperate actively with Texas and Arizona personnel on developments for those States. Studies of inheritance of economic characters and of breeding systems for best progress are conducted. At Charleston, S. C., work is done to develop disease-resistant, hardy, nonbolting, productive cabbage of high quality for the Southeast and to develop basic genetic information. Breeding sweet corn for resistance to earworm damage and to Helminthosporium leaf blight along with superior eating quality and adaptability to Southern growing conditions is being done at the U. S. Vegetable Breeding Laboratory at Charleston, S. C. Research is being initiated also on breeding broccoli at this laboratory.

The Federal scientific effort devoted to research in this area totals 5.2 professional man-years. Of this number 4.0 are devoted to breeding and genetics; 0.6 to diseases; 0.5 to variety evaluation; and 0.1 to culture.

A research project has been conducted in Poland sponsored by Public Law 480 funds on the nature of premature bolting (buttoning) in cauliflower. The problem is serious in transplants and cauliflower plants that "button" yield no marketable product.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Head Lettuce. Efforts have been continued to develop better adapted varieties of lettuce with resistance to downy mildew, mosaic, tipburn, big vein; and with superior eating qualities.

a. At La Jolla and Brawley, Calif. In cooperation with the California Agricultural Experiment Station about 55 backcrosses of downy-mildew resistant segregates of head lettuce were made to commercial varieties such as Caravan, Forty-Niner, Climax, and Vanguard. The purpose of the backcross program is to up-grade the horticultural characters of the resistant material, while simultaneously retaining the gene for downy mildew resistance. About 650 lines heterozygous for downy mildew resistance were tested in the greenhouse and those homozygous for susceptibility were discarded. Seed of about 250

resistant backcross progenies was produced in the greenhouse, and sent to the Imperial Valley or the Lower Rio Grande Valley for field testing. About 1,000 selections were made in the field at Brawley for superior horticultural characters.

Four selections of cos type lettuce, derived from the original cross, Parris Island x Dark Green, were tested in commercial fields in San Diego County. One line was superior in performance to either parent and is being considered for release.

b. At Salinas, Calif. In cooperation with the California Agricultural Experiment Station improvement of crisphead lettuce for horticultural traits continued. The Golden State type, 6583, was released under the name Francisco after extensive testing. Three lines of the Vanguard type were tested in commercial fields in the Salinas Valley.

In the 1962 spring nursery, 154 plants were selected on the basis of horticultural characters and tipburn tolerance. Of these, 33 were of mosaic and were planted in the spring nursery for 1963. Also planted in the 1963 nursery were 37 lines selected originally in 1961 and increased in the greenhouse for one generation to eliminate mosaic, and 27 F₂ lines from a complex cross involving Great Lakes 118, Francisco, and Vanguard.

Resistance to Big Vein. From the 1962 big vein resistance nursery, 41 selections were made on the basis of favorable horticultural characters. There was no big vein infection in the nursery; hence it was not possible to select for resistance to this disease. The progenies from these selections were planted in the spring nursery, and in a commercial field with a history of big vein infection.

Transfer of mildew resistance into recently released varieties was initiated with a cross between Vanguard, a susceptible variety, and Calmar, a resistant one.

Resistance to Mosaic. In the search for resistance to lettuce mosaic, 5 varieties and 336 lines irradiated with X-rays or thermal neutrons were inoculated and evaluated for the first time. Second generation testing was done on 131 lines from plants which survived the first inoculation series. One line which first showed resistance in 1961 still shows resistance after being tested twice more. Two Lactuca serriola plant introductions (PI. 251245 and PI. 251246) and Lactuca saligna (PI. 261653) with apparent resistance to mosaic were subjected to further tests and thus far appear to be resistant. Crosses were made between the Lactuca serriola lines and crisphead type. In the quantitative resistance program populations from two crosses were grown and will be tested this year.

Male Sterile Gene. The initial work on a male sterile gene has been completed and results submitted for publication. An investigation to determine the possible use of this male sterile gene in the development of F_1 hybrids in lettuce has been initiated. In quantitative genetics, two diallel analyses of earliness and height, in Collinsia heterophylla are being conducted.

c. Lower Rio Grande Valley. In cooperation with the American Refrigerator Transit Company, the Texas Citrus and Vegetable Growers and Shippers, and the Texas Agricultural Experiment Station, crisphead and cos type lettuce, adapted for culture in the area, and resistant to downy mildew are being developed. From a September planting of 548 progenies, 300 selections resistant to downy mildew were made and transferred to the greenhouse for producing seed. In this planting, a number of plants were selected from 9 progenies with exceptionally good horticultural type, and which were homozygous for resistance to downy mildew when tested in the greenhouse. Seed from plants of each of the 9 progenies is being increased in the field for use in yield trials of commercial scale. The October planting consisted of 880 progenies (673 advanced generation, and 107 F_2 's) from which 475 selections were made, 86 of them from F_2 progenies; all selections were transferred from the field to the greenhouse to obtain seed.

Tests of a promising line of cos or romaine lettuce were continued. This line (Texas 1047) appears to be extremely uniform, homozygous for resistance to downy mildew, and superior in several other respects to commercial varieties. Release of Texas 1047 is underway.

2. Spinach. The objectives of the spinach investigations are the development of high quality, productive varieties, hybrids, and breeding lines resistant to white rust (Albugo), mildew (Peronospora), blight (cucumber mosaic virus), and cold damage.

a. In New Jersey. In cooperation with Seabrook Farms Company, 3 lines and 2 hybrids combining immunity to 2 races of mildew and "blight" were superior in adaptability and processing quality to standard varieties in the 1962 trials. These items will be included in dates of planting trials in 1963 to determine a fall planting sequence that will insure a continuous and abundant supply of high quality spinach throughout the fall season.

b. In Arkansas. Savoy spinach hybrid 612 is rapidly replacing the standard varieties for processing and fresh market in the Arkansas River Valley.

c. In Maryland. Of the 5 lines and 5 hybrids advanced to grower trials, 2 lines and 4 hybrids produced excellent yields of good quality spinach in spite of the unseasonably cold weather in late October and early November. Two of the 16 new hybrid entries in the preliminary trials also withstood the cold weather without damage. Savoy spinach hybrids 56 and 612 produced excellent yields of high quality spinach in Maryland in 1962.

Evaluation for Resistance to White Rust. Plants from paired matings were screened at Beltsville for resistance to white rust. The survivors were evaluated for horticultural characters, and the most promising plants were pair-mated for seed production. These lines were planted in Texas to evaluate white rust resistance under field conditions.

d. In Texas. At Weslaco, Texas, 5 savoy lines, 9 savoy hybrids, and 12 semi-savoy hybrids with immunity to mildew and resistance to "blight" were evaluated for adaptability and processing quality. Because of increased interest in frozen spinach, 5 savoy lines and 5 hybrids will be included in grower trials in 1963.

3. Sweet Corn

a. Experimental hybrids. The following hybrids were repeated in the Southern Cooperative Trials: W-Q-6-A x H-3-D, IDR-1-A-B x 97-12-A-C, I39A-5-2 x 1715-B, and LeF-2-A x H-3-D. The last was nominated for the replicated trial. Three new hybrids were added to the replicated trials this year: 2015-1-1 x H-3-B, 4206-3-1 x K-A-B, and 4206-3-1 x H-3-B.

b. Adaptability of inbreds in Idaho. About half of the inbred lines developed at Charleston appear to be well enough adapted to commercial seed production in Idaho. Tassell blast and smut, neither of which is prevalent in the Charleston area, were important limiting factors.

c. Release of inbreds. The following inbreds are being increased for release to seedsmen for nicking tests with their materials: W-Q-6-A, M97-12-A-C, M118-8-C, M822-A, H-3-B, K-A-C, and LeF-2-A. M2015-1-1, and M4206-3-1 are also promising inbreds and may be released at some later date.

d. Recent acquisitions. Fourteen of the 151 Glenn Smith inbreds grown had an earworm resistance rating between 4.0 and 4.8. Two with ratings of 4.6 and 4.7 were otherwise unsatisfactory. Seven had a range of 4.1 and 4.3. The most resistant (4.78) has other desirable characteristics. Inbred 5136 from Iowa State, carrying a fertility restoring gene, had an earworm resistance rating of 4.23.

e. Parthenogenesis. The lack of parthenogenetic ears in two extensive plantings of male-sterile inbreds grown in 1961 and 1962 suggests that cytoplasm that fails to produce normal pollen is not conducive to parthenogenetic development.

4. Cabbage.

a. Adaptability. More than 300 families were planted during the fall of 1961. Eighty-eight percent of the 19,500 plants produced marketable heads. This includes selections from progeny of the cabbage-collard cross. More than 500 heads were selected for seed production.

b. Seed Production. Total seed production from 109 isolation plots in the Charleston district was adequate to maintain the lines, conduct disease tests, and to supply cooperators with seed of 45 lines. Seed from 74 self-pollinated selections was produced in the screenhouse. A method to produce seed in the greenhouse during the fall and early winter from the spring crop selections for slow bolting, has been successful. A method is being worked out to isolate plots in the fall where the selections are made from the spring crop.

c. Glaze. Some very attractive glaze selections have been made from several families. "Glaze" indicates a leaf surface without the characteristic waxy "bloom" of most varieties. This glaze factor, with a complicated inheritance, comes from two sources--a local collard of unknown origin that had been maintained in a family garden for many years and from Early Fuji cabbage from Japan. Neither source was uniform for the glaze character. Present evidence indicates glaze is not a simple recessive. Pure lines are being developed for a genetic study. Some of these glaze cabbage lines are extremely resistant to low temperatures. Some very attractive plants at the bud and mature heading stage have recently withstood a sudden low of 6° to 8° F.

d. Self-incompatibility. In the pure line work selection pressure is being given to genes producing degrees of self-compatibility that will be useful in future hybrid cabbage development. There is a possibility that the genes for glaze could serve as a market for hybrid production.

e. New White-head Cabbage. A mature collard of normal size with outer green leaves and a white central growing point was found in a commercial planting. This collard was crossed with normal heading cabbage during the spring of 1958. Several very attractive white-head cabbages have been produced. A very attractive feature of this selection is an irregular green border of the inner wrapper leaves.

f. Ascorbic Acid. Determinations were made on 520 heads of cabbage representing 19 families from the fall crop and on 107 heads representing 14 families from the spring crop. Ascorbic acid content ranged from 4.7 to 77.8 and from 37.0 to 78.9 mg/100 gm fresh weight for the fall and spring crops respectively. The average was 51.4 and 51.7 mg/100 gm for the two crops respectively. This is slightly higher than in previous years.

g. Plant Size. The production of medium to large plants from the self-pollination of dwarf, and conversely the production of populations lacking large plants from the self-pollination of large are fairly consistent aspects of this study of the inheritance of plant size. It is postulated that all sizes have the genetic potentiality for large size, but other factors control the expression of the genes for size.

D. Culture.

1. Cauliflower. A research project conducted with P. L. 480 funds in Poland on buttoning of cauliflower was concluded and a final report prepared. Several cultural and genetic factors were found to influence incidence of buttoning, particularly the age and size of the plants when subjected to "shock" upon transplanting to the field.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

A. Breeding.

Whitaker, Thomas W., Edward J. Ryder, and Orin A. Hills. 1962.

Lettuce and Its Production. ARS, U.S. Department of Agriculture Handbook 221, 49 pp.

Ryder, Edward J. 1962. Genetic effects of radiation. The Filter 24:3-8.

Ryder, Edward J. 1963. A gene for depth of corolla cleft in the lettuce flower. Vegetable Improvement Newsletter 5:5-6.

B. Diseases.

Smith, Paul G., R. E. Webb, and C. H. Luhn. 1962. Immunity to Race 2 of Spinach Downy Mildew. Phytopathology 52:597-599.

C. Variety Evaluation.

Hall, B. J., G. A. Sanderson, T. W. Whitaker, and T. M. Little. 1963.
Variety Trials of Cos or Romaine Lettuce in San Diego. Calif.
Agric. 17:8-9.

D. Culture.

Skapski, H. 1962. The Influence of Environmental Factors on Button-
ing of Cauliflowers. May 25, 1960-August 31, 1962. Final Report
P. L. 480 Project No. E21-CR-9.

MELON AND OTHER CUCURBIT CULTURE,
BREEDING AND GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The major problems of melons, cucumbers, and related crops involved disease control through breeding or other means to permit production of optimum eating quality and yields. Varieties of good to excellent eating quality potentials often suffer serious field losses from disease, and the consumer is increasingly dissatisfied with poor quality that is due to diseases and premature harvest, especially in muskmelons. Improved carrying quality is needed. Resistance to some serious diseases is unknown, and available resistance to others has proved difficult to combine with the other economic characteristics needed. A disease complex of muskmelons called crown blight has seriously reduced production and acreage in the Southwest and is not yet controlled. Potentials of F_1 hybrids and methods of their economical production need extensive study. Adaptation of the cucumber plant to mechanical picking and improved suitability of cucumbers for processing are desired.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, horticulturists, and plant pathologists engaged in both basic and applied research on melons and cucurbits. Muskmelon breeding and genetic studies are conducted at La Jolla, Calif., Brawley, Calif., and Charleston, S.C. Watermelon breeding is done at Charleston. Applied breeding of early, hardy cucumbers and squash is done at Cheyenne, Wyo. Disease research, with emphasis on crown blight of muskmelons, is done at Beltsville, Md., and Yuma, Mesa, and Tucson, Ariz., in cooperation with the Arizona Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 4.6 professional man-years. Of this number 2.9 are devoted to breeding and genetics and 1.7 to diseases.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Muskmelons

a. Breeding for multiple disease resistance. In cooperation with California, Arizona, and Texas Agricultural Experiment Stations 200 powdery mildew-resistant, crown blight-tolerant derivatives of resistant cantaloup $P_3 \times 45 \times 450_3$ were evaluated in the field and selections made in spring plantings in a 12-acre block at Brawley and in

smaller blocks at several locations in California, Arizona, and Texas during 1962. Growers were favorably impressed with several of those lines that resemble the PMR No. 45 and No. 450 varieties but have greater disease resistance. Selections from nine lines were increased in isolated blocks at Brawley, Davis, Meloland, and Riverside, Calif.; Mesa, Ariz., and Weslaco, Tex., during the summer. Individual fruits were indexed for powdery mildew resistance at La Jolla and a few were used in controlled breeding work at La Jolla and Davis.

Twenty-four powdery mildew-resistant, crown blight-tolerant cantaloup derivatives of the crosses PMR No. 45 x Hale's Best and PMR No. 45 x Texas 123 were evaluated and used for selection in a one-acre block at Brawley during spring.

Two hundred derivatives of crosses of a PMR muskmelon with Honey Dew were tested in a three-acre block at Brawley and a half-acre block at Blythe during spring 1962. Lines from 14 crosses in 1945 and 1946 were reduced to those of 3 crosses in the early years. The work is now concentrated on F_3 to F_5 progenies from third and fourth delayed backcrosses to Honey Dew from the cross with PMRinbred 33186. Those progenies appear superior to commercial lines in adaptation, resistance to powdery mildew and crown blight, and fruit quality. Selections were indexed for resistance to powdery mildew and 21 of these were used in controlled breeding work at La Jolla.

Thirty-seven early-generation derivatives of first and second backcross to the Crenshaw variety, from crosses with three PMR muskmelons, were evaluated and used for selection in a quarter-acre block at Brawley. Several plants produced fruits comparable with the recurrent parent. Like that variety, those similar to it in appearance were also very sensitive to sunburn. Forty-four Crenshaw hybrids were selfed and used in crosses at La Jolla.

b. Breeding for resistance to melon viruses. Forty stocks selected for resistance to CMV (cucumber mosaic virus), WMV (watermelon mosaic virus), or TRSV (tobacco ringspot virus), in controlled experiments at Beltsville, were evaluated for field performance at Brawley, Calif., and Yuma, Ariz. Twenty-four were evaluated at Weslaco, Tex. Most of these stocks were ill-adapted to culture in the Southwest, were very susceptible to powdery mildew, downy mildew, and one or more of the viruses present in the three areas used had poor fruit quality. Virus resistance remains to be combined with resistance to other diseases and with good commercial qualities.

F_1 selections (from heterozygous parents) with resistance to both powdery mildew and WMV were outstanding in field performance at La Jolla where both diseases occurred during summer. Those selections were crossed with several high-quality parents to develop improved fruit quality.

Controlled studies at Beltsville, Md., on the genetics of resistance to CMV demonstrated two recessive factors for resistance approaching immunity in resistant parent 34340. Studies on dominance vs partial dominance of the allelic genes for susceptibility were initiated at Beltsville and La Jolla.

Controlled inoculation studies cooperative between the Beltsville, Md., and western locations on the genetics of resistance to WMV demonstrated two, possibly three, dominant genes for resistance to that disease. Studies on gene interactions are in progress.

Several WMV-resistant and CMV-resistant stocks were crossed with varieties and PMR-resistant breeding lines at La Jolla. Some of these lines were advanced to the F_3 and second backcross generations in WMV-resistance and CMV-resistance controlled tests in the greenhouses at La Jolla during 1962.

Pollen from resistant selections was successfully shipped in ordinary envelopes from Beltsville, Md., to La Jolla, Calif., in 1961.

c. Breeding for resistance to crown blight. At Mesa, Ariz., in cooperation with the Arizona Agricultural Experiment Station, a search was made among Arizona muskmelon breeding lines for resistance to the widespread WMV. Several lines failed to develop symptoms after repeated inoculations with one isolate of the virus, some lines were symptomless carriers of the virus, and others remained entirely free of virus. Progeny tests show that some highly virus-resistant lines segregated for resistance and susceptibility and others remained virus free. The virus-resistant germplasm is different from the resistant material found in the Beltsville screening tests in 1961. Cucumber mosaic virus-resistant germplasm is being incorporated into the crown blight resistance breeding program.

At Mesa, Ariz., in cooperation with the Arizona Agricultural Experiment Station, studies were continued through careful selection, hybridization and testing to obtain resistance or tolerance to crown blight in muskmelon. A number of crown blight resistant or tolerant lines have been developed. Studies indicate that resistance to crown blight is conditioned by complex genetic factors probably closely linked with factors conditioning soft fruit flesh and wet cavity. Seed has been increased from one promising stock for field testing in 1963.

d. Bush type cantaloups. Two "bush-type" cantaloups from Texas and derivative F_1 and F_2 hybrids were evaluated for adaptation to machine harvest at Davis, Calif., during summer.

e. Genetic studies. These studies are designed to gain fundamental information on the nature of the genetic mechanism and natural breeding behavior in the muskmelon, to obtain markers for selection of

resistant plants where disease epidemics fail to occur, and to obtain seedling markers linked with male sterility to aid in the commercial production of F_1 hybrids.

Information was obtained at La Jolla and Brawley on the presence or absence of linkage between the genes Pm^2 (powdery mildew resistance), n (nectarless), msl and ms^2 (male sterile). The genetics of male sterile 2 was worked out. Additional populations were produced for studies on linkage and powdery mildew genetics.

f. Development of breeding methods. In a cooperative study by the Charleston, S.C., and western projects to compare efficiency of breeding procedures, three hybrid cantaloup populations were subjected to mass selection in two 300-hill blocks and one 1,000-hill isolation block at Brawley during spring and summer. Evaluation of one block is scheduled for 1964 and 1965.

2. Watermelons

a. Release of variety and breeding lines. The variety Graybelle was released to seedsmen in December and 18 firms requested breeders stocks for increase. Graybelle should fill a genuine need for an early variety in the 15-18 pound class which had dependable quality. Released at the same time to commercial breeders were three tetraploid stocks and two related diploid stocks for the production of experimental triploid hybrids. Triploid (seedless) hybrids are still relatively unknown to consumers, but they have possibilities for greatly improved eating quality and should become popular when better parental combinations are found.

b. Breeding methods. Use of minimum isolation plots, with 30-foot separation by other vine crop barriers, has been extended with watermelons, and selections from these plots are planted in alternate generations in the greenhouse for systematic sib-crossing. In this program were 40 minimum isolation plots and 18 full isolation plots in the field and 32 greenhouse plots for selfing and sib-crossing.

c. Tetraploid breeding. The tetraploid of Graybelle has several of the advantages of a good triploid, including few seed, extra hard rind, extra firm flesh, and long-keeping quality. Work is under way to improve the level of fertility so that fruit will set abundantly and still retain a much reduced number of seed per fruit. Cost of seed is such a tetraploid would be greater than that of diploids but much less than the cost of triploid hybrid seed. There is a delicate balance of seed per melon and quality of flesh which perhaps can be stabilized by suitable breeding techniques.

d. Single cross hybrids. Several F_1 hybrids performed better than either parent. The degree of superiority was not dramatic but probably was sufficient to make their commercial use economical.

3. Cucumbers

At Cheyenne, Wyo., in cooperation with the Wyoming Agricultural Experiment Station, seven P.I. numbered cucumbers from Japan were added to the cucumber breeding program. These are very long slicer types, four of which are gynoeocious.

One greenhouse summer crop was grown with crosses involving F_1 and F_3 generations. Selections were made of near spineless, well colored slicing types. F_1 hybrids between Jalalabad, Ashley, and Spartan Dawn were made with the Japanese types.

A field planting of 69 hybrid lines, 8 varieties, and the 7 Japanese lines was made, but was totally lost in the hailstorm of 7/1/62.

4. Other Cucurbits

At La Jolla, 12 species of Cucurbita and 56 progenies representing various interspecies hybrids were grown in the field. Notes, observations, and photographs were taken as part of a plan for developing a sound theory of the origin and domestication of this group. Some progress was made in transferring powdery mildew resistance from C. lundelliana, a wild species, to commercial type cultivars.

B. Diseases

1. Muskmelons

a. Stem blight. At Yuma, Ariz., in cooperation with the Arizona Agricultural Experiment Station, a stem blight on Persian melons was found to be caused by a Macrophomina spp. and tests indicated seed transmissions of the organisms in this melon. Seed harvested from diseased fruit of Acorn squash, watermelon, cantaloup, Casaba, and Crenshaw did not transmit the organism in field planting trials in 1962.

b. Virus studies. At Beltsville, Md., studies under controlled conditions indicated that the concentration of the CLV (cucurbit latent virus) was materially increased in muskmelon if infection was accompanied by infection with the WMV. Melon plants infected with both viruses developed more severe foliar symptoms and crown leaf decline, and were more severely stunted than plants infected with WMV alone. In these tests, dead or dying melon plants were also infected with a Fusarium spp.

At Beltsville, Md., in cooperation with the Virology Laboratory, an antiserum was developed against the watermelon mosaic virus isolate T-16. This antiserum is reactive with certain WMV isolates from the southwestern areas of the United States but not with other isolates

infecting watermelons from the same areas. All isolates tested were aphid-transmitted, highly infectious to muskmelons and other cucurbits, and have similar physical properties. Further studies are in progress to develop additional antisera and determine exact relationships among WMV isolated from the south, southwest, and northwest United States.

At Beltsville, Md., an unidentified virus infecting muskmelon on the Mesa, Ariz., Experimental Station has been isolated. Preliminary studies indicate it is not closely related to the viruses commonly found in cucurbits. Preliminary host range studies indicate certain ornamentals are the overwintering hosts for this virus. (Coop. Ariz.)

At Weslaco, Tex., in cooperation with the Texas Agricultural Experiment Station, studies were continued on soil transmission of the tobacco ringspot virus so prevalent in the Rio Grande Valley in various cucurbits and other vegetables. Soil transmission of the virus was obtained to cucumber, squash, and eggplant under greenhouse conditions; however, a nematode was not established as the vector in these studies.

c. Virus surveys. In cooperation with the Arizona Agricultural Experiment Station, surveys of melon fields in the Yuma area and in Central Arizona indicated a low incidence of late virus infection. Virus infection was not a notable factor in melon production in Arizona during 1962.

A 4-month survey of cucurbit viruses in cucurbits and other crops, weeds, and ornamentals in the Imperial Valley, conducted in cooperation with Beltsville revealed the presence of CMV in ornamentals during winter but it failed to reveal the original source of the more prevalent WMV. A slower, erratic buildup of viruses in cucurbits in 1962, as compared with their sudden buildup in the 1940's and early 1950's, appeared to be correlated with a slower and lower total population buildup of green peach aphids.

d. Cultural practices affecting disease. At Yuma, Ariz., in cooperation with the Arizona Agricultural Experiment Station, studies on the effects of organic matter such as barnyard manure and winter green manure crop of papago peas, with recommended fertilizer practices, indicated these treatments did not materially influence the incidence of muskmelon diseases. The addition of calcium cyanamide at rates of 700 pounds per acre was also ineffective. These studies were discontinued.

2. Watermelons

At Yuma, Ariz., Tifton, Ga., and Prosser, Wash., in cooperation with each State Agricultural Experiment Station, fruits of locally grown watermelon varieties were affected by virus-like ringspot symptoms.

Repeated isolations from affected fruit and plants indicated an association of ringspot symptoms and WMV at Yuma. Experiments at Yuma failed to show that evaporation of water containing various salts simulating leaf exudates from the fruit surface was directly correlated with the ringspot symptoms. Additional studies are planned for 1963 at all three locations.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Breeding

- Bohn, Guy Weston and L. K. Mann. 1960. Nectarless, a yield-reducing mutant character in the muskmelon. Proc. Amer. Soc. Hort. Sci. 76: 455-459. (Omitted from earlier reports).
- Bohn, G. W. and T. W. Whitaker. 1962. Abstracts, Proc. Amer. Soc. Hort. Sci., Corvallis, Oregon, August.
- Bohn, G. W., T. W. Whitaker, and G. N. Davis. 1962. Potential desert melon varieties. Western Grower and Shipper 33(2):18,25.
- Whitaker, T. W. and G. N. Davis. 1962. Cucurbits, botany, cultivation and utilization. Leonard Hill (Books) LTD, London. 250 pp.

Diseases

- Webb, R. E. and G. W. Bohn. 1962. Resistance to cucurbit viruses in Cucumis melo. (Abstract). Phytopathology 52:1221.

MUSHROOM BREEDING AND GENETICS, DISEASE AND CULTURE
Crops Research Division, ARS

Problem. Materials and methods of the old craft of mushroom production no longer suffice under current conditions. Considerably more information on the cytogenetics of the common mushroom is needed to permit controlled "breeding" and improvement. Extensive basic studies of the microbiology of the composting materials, nutrition and environmental physiology of various fungi, and the diseases and cytogenetics of edible fungi must be conducted to place the industry on a sound footing.

USDA PROGRAM

Applied and basic mushroom studies are conducted at Beltsville on the control of a number of mushroom diseases and in determining the thermal death points of both beneficial and harmful micro-organisms of compost as a basis for more efficient composting and disease control. Research is conducted on preparation of "artificial" or substitute composts and nutritional and environmental effects on mushroom growth, yield, and quality. In addition, studies are underway to devise effective breeding and genetic studies to improve mushroom strains in yielding ability and quality. Two professional man-years were involved in F.Y. 1963.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

1. Strain Improvement.

a. New methods. Studies made in 1961 indicated that "pairs" of spores from individual basidia are frequently discharged simultaneously, and that paired spores remain together while falling for at least a meter. During the past year, methods were devised for collecting, germinating, and isolating these paired spores to facilitate genetic studies. An apparatus was constructed which made it possible to expose an agar plate to falling spores for a fraction of a second so that in many places on the agar a single pair of spores can be isolated in an area of 5 to 10 square millimeters. Also, means were developed to stimulate spore germination so that both spores in a pair frequently germinate together. This spore germination was accomplished by collecting the spore "prints" on Saboraud's agar and subjecting them to gases produced by growing mushroom mycelium.

b. Strains of spawn. Valuable new strains of mushroom spawn are sometimes obtained by making tissue cultures from mushrooms that appear to

have especially desirable characteristics. Accordingly, a series of experiments was made to test whether tissue cultures made from mushroom stems were like those made from caps and whether strain differences could be expected to occur frequently among cultures derived from different mushrooms grown from the same spawn strain. In these experiments there was no measurable difference between strains of spawn made from the stems and those made from caps of 5 separate mushrooms.

2. Pesticide residues in compost. Different pesticide chemicals may be added to compost in practice to control mushroom pests. Little is known of the effect of compost and the unique nature of the conditions for growing mushrooms on such pesticide chemicals. The chlorinated insecticides: lindane, p,p'-DDT, heptachlor, aldrin, and dieldrin were incorporated (50 ppm) into different batches of compost just before inoculation of the compost with mushroom spawn. At 19, 25, 39 and 70 days after first picking of mushrooms, samples of the different composts were analyzed for the pesticide initially added. A semi-quantitative paper chromatographic method capable of distinguishing between the pesticide and its degradation products was used.

Aldrin was almost totally converted to dieldrin (the stable epoxide form) within 3 weeks. Approximately 5-10% of the initial DDT added was converted to related products. Neither lindane nor dieldrin appeared to be degraded within 70 days in the compost. Analysis of mushrooms (by methods cited above) grown on pesticide-treated compost failed to demonstrate the presence of any of these insecticides in the mushroom. Fatty substances extracted from the mushroom, however, interfered in the chromatographic method. The high degree to which these insecticides could be recovered chemically from composts suggests a possible potential danger of applying "spent" compost treated with pesticides to soil in which sensitive crops may be grown.

3. Casing Soil and Pesticide Residues. Studies were initiated on the effects of certain chemical substances in casing soil on the growth and development of cultivated mushrooms. Many chemicals used as pesticides were included because of the possibility of chemical contamination of field soils used to case mushroom beds.

Twenty substances were singly incorporated in casing soil at 5, 20, 50, and 500 ppm and tested for their effects on the initiation and growth of the fruiting bodies of cultivated mushrooms.

The chemicals tested were: captan; maneb; zineb; atrazine; CIPC; DNBP; 2,4-D; monuron; amitrole; aldrin; chlordane; p,p'-DDT; dieldrin; heptachlor; lindane; methoxychlor; Kelthane; coumarin; maleic hydrazide; and naphthalene acetic acid.

None of the substances tested was found to stimulate mushroom production. Almost all substances induced some degree of inhibition and injury. The threshold concentration of injury was about 5 ppm of chemical in the casing soil. Inhibition occurring on only a part of a mushroom bed resulted in increased yield on non-inhibited areas. Inhibition occurring on the entire mushroom bed resulted in decreased number and yield of mushrooms but with an increased weight per individual mushroom. Yields in some cases increased with time because of physical and degradative losses of inhibitor; adaptation of the mushroom to the inhibitor; or the failure of some chemicals to affect the "fruit body initials system" after the system became established.

Analysis of these results indicates that in practice field chemical contamination of casing soil is an improbable cause of commonly observed inhibition effects. Chemical injury in commercial practice appears to be more probable from chemicals incorrectly applied to casing soil by the mushroom grower himself.

4. Casing materials. Tests were made of the feasibility of using peat moss for casing mushroom beds. Yields were compared from test trays covered with clay loam casing soil and with various mixtures of peat moss, ground limestone, and sand. When sterilized by heating to 160°F to eliminate nematodes, the peat and limestone mixtures provided a satisfactory substitute for clay loam. Trays covered with peat moss mixed with 10 to 25% limestone (weight basis) yielded slightly better than trays covered with a mixture of equal amounts of peat and limestone. In commercial practice the feasibility of substituting a peat mixture for clay-loam casing will depend on 3 factors: cost, adequate sterilization procedure, and the mushroom grower's skill in modifying watering practices to meet the new requirements of the peat casing mixture.

SEED CROP CULTURE,
PHYSIOLOGY, NUTRITION AND HARVESTING
Crops Research Division, ARS

Problem. Although the vegetable seed industry normally produces adequate quantities of seeds, in seed production there is still too much risk, too low economic efficiency, and too much variability in quality. The industry is geographically concentrated, and thus subject to localized hazards which could drastically affect the entire national vegetable production and processing industries. The vegetable seed industry has developed to its present level almost entirely by trial and error. Now the development of high mechanized methods in vegetable production is demanding the production of higher quality seeds. However, basic knowledge is lacking on the physiology of seed development, maturation, and germination, particularly in reference to the crop producing potential of the seeds. Thus, applied research by industry and government lacks the sound scientific basis necessary for future advances.

USDA PROGRAM

Basic research on the physiology and biochemistry of vegetable seed germination and seedling vigor is carried out at Beltsville, Maryland. Through this year cultural studies on the effect of soil moisture, cutting times, and curing methods have been carried out at Logan, Utah, and Twin Falls, Idaho, in cooperation with the State Agricultural Experiment Stations. With the conclusion of this year's activities, emphasis is being shifted from cultural studies to more basic research on the physiology of seed development, especially in relation to such seed quality factors as light and temperature sensitivity, dormancy, and seedling vigor. Federal scientific effort totals 3.0 professional man-years, of which 1.6 are on physiology and 1.4 on culture of vegetable seeds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Production of Pea Seed. At Logan, Utah, an experiment on production of pea seeds involving 6 levels of irrigation and 6 times of cutting was completed. Because the growing season was extremely cool, yields were high and seed development slow. Although data analysis is not complete, the results provide useful information on the contrast between this type of season and normal seasons when seeds mature quickly under higher temperatures. Measurements of seed temperatures during growth and maturation showed great variability, even within the seeds in a single pod. Variability factors included mean temperature, daily high and low temperatures, and range of diurnal temperature fluctuations. Recognition of these variables raises the question of whether temperature differences between developing seeds merely cause quantitative changes in rate of development, or whether they can also introduce qualitative differences which account for

population variability in such seed quality factors as speed of germination and emergence.

Germination and Seedling Vigor. At Beltsville, Maryland, changes in ribonucleic acid (RNA) and acid soluble nucleotides (ASN) have been measured in green (normal vigor) and bleached (low vigor) lima beans. There is no evidence of major differences between low and normal vigor seeds in the amounts of these classes of compounds. However, major changes were found to occur in these compounds very early in germination, even before the seeds were fully imbibed. Because of the critical role that RNA and ASN are known to play in normal growth processes, present results suggest that the production of these compounds may play a key role in the control of germination, as well as in subsequent growth. Although these particular compounds do not now seem to be primarily concerned with the differences in seedling vigor, other data indicate rather large differences between green and bleached seeds in the rate of water uptake and response to temperature.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Hawthorn, L. R., Toole, E. H. and Toole, Vivian K. 1962. Yield and viability of carrot seeds as affected by position of umbel and time of harvest. Proc. Amer. Soc. Hort. Sci. 80:401-407.

WEED AND NEMATODE CONTROL

Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals and biological methods on vegetables.

USDA PROGRAM

The total Federal scientific effort devoted to weed control research is 66.5 professional man-years, of which 2.7 are devoted to work on vegetables at Beltsville, Maryland; New Brunswick, New Jersey; Tifton, Georgia; and Weslaco, Texas.

The total Federal scientific effort devoted to nematode control research is 21.5 professional man-years, of which 2.3 are devoted to work on vegetables at Tifton, Georgia; Charleston, South Carolina; and Weslaco, Texas.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Weed Control

1. Physiological and Ecological Studies. The micro environment greatly influences the effectiveness of herbicides used under field conditions. At New Brunswick, New Jersey, petroleum mulches have been used in an attempt to stabilize soil-applied herbicides by minimizing changes in soil-micro environment. These studies using sweet corn, squash, cantaloupes, and snapbeans showed that the length of the active herbicidal period of some herbicides was increased when they were either incorporated in or applied beneath a petroleum mulch. The performance and persistence were different for each herbicide. Thus, herbicidal activity of amiben, diuron, simazine, atrazine, 2,4-D, diphenamid, and 2-chloroallyl diethyldithiocarbamate (CDEC) + isopropyl N-(3-chlorophenyl) carbamate (CIPC) were enhanced by petroleum mulches, and variable or reduced activities were observed with ethyl di-n-butylthiolcarbamate (R-1870), dicryl, N-1-naphthylphthalamic acid (NPA) and DNBP.

Studies on the use of soil incorporation as a means of minimizing the effects of environment on the persistence of herbicides at Tifton, Georgia, involving EPTC, PPTC, and dichlobenil showed that soil-incorporated treatments of EPTC at 1/4 lb/A gave satisfactory weed control for several weeks. Preemergence rates were much less active. The composition of solvents used in application also affected persistence of soil-applied thiolcarbamates.

It has been clearly shown that methods of using soil-applied herbicides in areas of abundant rainfall are not effective in arid regions. At Weslaco, Texas, CDEC and EPTC incorporated to various depths in the soil were most active at the 0.5 and 3 inch levels, respectively, and differential soil temperature did not play a major role in this differential performance.

At Weslaco, Texas, preemergence applications of diuron, prometryne, 2,4-dichlorophenyl-4-nitrophenyl ether, DCPA, and CIPC were evaluated for weed control in sprinkler-irrigated and furrow-irrigated cotton and for their residual effects on lettuce in rotation. The stands of lettuce were reduced by diuron. These studies suggest alternate herbicides that may be used on cotton to avoid injury to subsequent vegetable crops. Postemergence applications of monuron, diuron, linuron, 2,4-dichlorophenyl-4-nitrophenyl ether, CIPC, DCPA, prometryne, and dichlobenil on furrow-irrigated cotton revealed that lettuce in rotation was injured by residues of diuron, monuron, and prometryne in the soil.

Wind velocity and many other climatic and environmental factors affect the performance and persistence of soil-applied volatile herbicides. Commercial growers have found that night application of the phenyl, thio, and thiolcarbamates, when air movement is at a minimum level, is most effective. At Beltsville, Maryland, experimental wind velocity chambers were designed and constructed for the study of air-movement as a factor in vaporization of herbicides. Studies on vaporization of EPTC revealed that changing the wind velocity in the range of 0 to 4 mph greatly increased the rate of herbicide loss.

Studies at New Brunswick, New Jersey, have shown that weed competition during the prefruiting period of tomato growth can seriously reduce crop potential and herbicides can provide continuing effective weed control during this period.

Physiological studies of tomato plants from herbicide-treated plant beds at Tifton, Georgia, show that treated and untreated plants have a wide variation in reducing sugars indicating unsuspected metabolic effects that may be reflected in growth in the commercial plantings. Research is continuing to assess the fundamental and practical importance of these findings.

Studies on sweetpotatoes at New Brunswick, New Jersey, using postplanting applications of amiben, dichlobenil, dicryl, CIPC, and diphenamid showed that flavor was slightly influenced at the higher rates of herbicide application but other quality factors were unaffected. Studies at Tifton, Georgia, showed that PPTC and DCPA have a tendency to lower quality and taste.

At Tifton, Georgia, studies on the competitive nature of nutsedge and sweetpotatoes indicate that sweetpotatoes may inhibit nutsedge growth by means of an inhibitory root exudate.

2. Control Studies. Eight advanced new herbicides were evaluated at Beltsville, Maryland, as preplanting soil incorporated, preemergence and post-emergence treatments of 12 summer-planted and 12 fall-planted vegetable crops. Among these herbicides, trimethylsulfonium chloride (SD-6623), ethyl-1-hexamethyleneiminecarbothiolate (R-4572), and ethyl *N,N*-diisobutylthiolcarbamate (R-1910) showed promise as preplanting and/or preemergence treatments on a number of vegetable crops. Two other experimental herbicides exhibited high herbicidal activity in preplanting treatments suggesting additional studies to determine their persistence as a basis for establishing practical methods of using them.

Cantaloupes - In research at New Brunswick, New Jersey, NPA, diphenamid, R-1870, and DCPA were compared as preemergence sprays in water, under petroleum mulch and mixed with petroleum mulch. The activities of NPA, diphenamid, and DCPA, but not R-1870, were reduced when mixed with the mulch. The crop showed a high tolerance to the NPA, diphenamid, and R-1870 treatments. The results in general do not offer encouragement for developing improved performance of these herbicides through the use of petroleum mulches. Preplanting, soil incorporated, and preemergence treatments with NPA, CDEC, EPTC, R-1870, and DCPA followed by furrow-irrigation at Weslaco, Texas, were evaluated on cantaloupes. Preplanting treatments with CDEC and DCPA were outstanding.

Squash - In experiments at New Brunswick, New Jersey, DNBP, amiben, and DCPA were compared as preemergence sprays in water, under petroleum mulch and mixed with petroleum mulch. The persistence of DNBP and amiben was increased by application in the mulch whereas the activity of DCPA was reduced.

Sweet Corn - In studies at New Brunswick, New Jersey, simazine, atrazine, DNBP, 2,4-D, CDEC $\frac{1}{2}$ CIPC, and diuron were compared as preemergence sprays in water, under petroleum mulch and mixed with the petroleum mulch emulsion. The crop was not injured by any of the treatments. Simazine and atrazine were equally effective with or without the mulch; the activity of DNBP was decreased by the mulch; and the activity of 2,4-D was extended.

Sweetpotatoes - Also at New Brunswick, New Jersey, amiben, dichlobenil, DCPA and diphenamid applied shortly after transplanting were effective without injuring the crop. CIPC applied at the same time caused injury symptoms and significantly reduced yields. At Tifton, Georgia, sweetpotatoes showed a high level of tolerance to EPTC, R-1607, diphenamid, amiben, and DCPA and effective weed control was obtained. Dichlobenil and trietazine were injurious to the crop. In a continuation of research on sweetpotatoes at Beltsville, Maryland, CIPC at 6 lb/A significantly reduced yields following two years of research in which injury was not experienced.

Tomatoes - Results of studies at Tifton, Georgia, using preplanting, transplanting and layby applications of PEBC, R-1870, diphenamid, CDEC, amiben, DMPA, trifluralin and PEBC + diphenamid indicate that PEBC, diphenamid and amiben offer promise for transplanted tomatoes on the soils and weed problems of the area. DCPA caused stem brittleness and resulting loss of plants. Studies of herbicides for control of weeds in direct-seeded tomatoes for transplants indicate that PEBC as a preplanting treatment and diphenamid as a preemergence treatment are most promising. In experiments at New Brunswick, New Jersey, tomatoes treated with diphenamid, propyl ethyl-n-butylthiolcarbamate (R-2061) and amiben in granular form at 3 or 8 weeks after transplanting did not reduce yield or quality and effectively controlled annual weeds. The early treatment with amiben caused temporary retardation of growth though yields were not affected. In research at Beltsville, Maryland, diphenamid, DCPA, and R-2061 applied as overall sprays at layby controlled many germinating annual weeds without affecting yield or quality nor causing foliar or other injury symptoms.

Nematode Control

1. Control Studies. In tests of 1401 Plant Introduction accessions of the genus Cucumis at Charleston, South Carolina, only one accession was found to be very highly resistant to the most common root-knot nematodes of the Southern States (Meloidogyne incognita acrita). The resistance will be studied with the hope that it can eventually be incorporated into commercial varieties of cucurbits.

In a test of interactions of irrigation, soil fumigation and herbicides at Tifton, Georgia, it was determined that nematode control was the most important factor in production of winter spinach. The soil was infected with both root-knot nematodes (Meloidogyne incognita acrita) and Fusarium solani. Average spinach yield in the irrigated plots treated with a nematocide (methyl isothiocyanate and dichloropropene) was 10.18 lbs. per plot when a herbicide (2-chloroallyl diethyldithiocarbamate) was used, and only 7.78 lbs. where the nematocide but no herbicide was used. Plots which were not fumigated produced less than a pound of spinach whether a herbicide was used or not. Unirrigated plots averaged 32% less than the irrigated plots.

In an experiment at Tifton, Georgia, treatment with a combination of methyl isothiocyanate and D-D Mixture, gave a ten-fold increase in yield of spinach. Application of sodium-N-methyl dithiocarbamate tripled yield, and applications of ethylene dibromide about doubled yield. All of the treatments controlled the root-knot nematode (Meloidogyne incognita acrita), and reduced damping-off caused by Fusarium solani.

The reniform nematode (Rotylenchulus reniformis) recently found to be a serious pest of cotton in Louisiana, also attacks sweetpotatoes. In experiments at Baton Rouge, control of this nematode by several standard and experimental nematocides was very good, best results being obtained with an application of technical dichloropropene. Yields on plots treated with this material averaged 235 bushels per acre as compared with 149 bushels for the control plots, an increase of 56%.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Weed Control

- Bruns, V. F. and Dawson, J. H. 1962. Weed control in asparagus with monuron and diuron. Wash. Agr. Expt. Sta. Bulletin 635.
- Danielson, L. L. 1963, 1962 Evaluation of herbicides on horticultural crops. USDA-ARS-CR-10-63.
- Menges, R. M. 1962. Chemical weed control in vegetables grown in the Lower Rio Grande Valley of Texas. Rio Grande Valley Hort. Soc. Jour. 16, pp. 89-91.
- Menges, R. M. 1963. Effect of overhead and furrow irrigation on performance of preemergence herbicides. Weeds, 11, pp. 72-76.
- Menges, R. M. and Hubbard, J. L. 1963. Preplanting and preemergence herbicide treatments in cantaloupes. Res. Prog. Rept. WWCC, p. 25.
- Taylorson, R. B. 1963. A preliminary investigation of the competitive effects of sweetpotatoes on the growth of Cyperus esculentus L. (Abstract) Proc. SWCC, p. 389.
- Welker, W. V., Jr. 1963. The influence of petroleum mulch upon herbicidal activity. Proc. NEWCC, pp. 89-90.

INSECT CONTROL
Entomology Research Division, ARS

Problem. Insects and mites are important limiting factors in the production of high-quality vegetables. They reduce the yield, lower the quality, spread plant diseases, contaminate the marketable product, and increase the cost of production. The use of insecticides and miticides is currently the most effective direct method of control; however, application too close to harvest may result in residue problems. There is concern over the possibility of contaminating milk and meat by feeding crop refuse or byproducts of peas, beans, sweet corn, or other vegetables treated with insecticides. The drift of certain insecticides into other fields or areas can also cause problems. Another difficulty is that a number of vegetable insects have developed resistance to certain insecticides. For many vegetable insects there is an increasing need for safe, effective, and economical methods of control that will not leave harmful residues on the marketable produce or adversely affect the flavor or quality. Research is needed on methods for better utilization of predators, parasites, and insect diseases of vegetable insects; the development of varieties of vegetables resistant to insect attack; the development and utilization of more effective traps and lures; an exploration of new approaches to control including radiation, chemosterilants, and antimetabolites; and an evaluation of insecticide application equipment. Such developments would help decrease the necessity for employing hazardous chemicals. Better methods are required to forecast possible insect damage before it occurs on vegetables, and to determine when it will be necessary and profitable for growers to apply control measures.

USDA PROGRAM

The Department has a long-term program of applied and basic research on vegetable insects with stations at Mesa, Ariz.; Riverside, Calif.; Tifton, Ga.; Twin Falls, Idaho; West Lafayette, Ind.; Beltsville, Md.; State College, Miss.; Forest Grove, Oreg.; Charleston, S.C.; Logan, Utah; Baton Rouge, La.; and Yakima, Wash., in cooperation with the respective State Experiment Stations and industry. Much of the work is in cooperation with the Crops Research, Pesticides Regulation, and Agricultural Engineering Research Divisions. The work in Idaho is also cooperative with the Idaho Bean Commission and that in Maryland with the Northern Utilization Research and Development Division and the Human Nutrition Research Division. The work in Oregon is conducted jointly with the Agricultural Engineering Research Division. The work in Louisiana is under contract by the Louisiana State Experiment Station.

The major objective of this work is to develop more effective and economical and less objectionable methods of controlling insect pests of vegetables in the field to reduce losses from these pests without leaving undesirable insecticide residues on or in the marketed product or in the soil, and

without affecting the flavor or quality of the product, and without adversely affecting beneficial insects. Increased emphasis has been given to new approaches to insect control. It is necessary to learn more about the biology and habits of the pest insects with the object of developing methods of controlling them without using insecticides. A widespread search is in progress for sex lures that can be utilized in insect detection and control, requiring a much better knowledge of mating habits of the various insect species. Also underway are studies of male sterilization techniques for such insects as the cabbage looper, drosophila, the banded cucumber beetle, and the Mexican bean beetle by means of gamma radiation and chemical steri-lant techniques that may permit insect control on an area basis.

The Federal scientific effort devoted to research in this area totals 26.8 professional man-years. Of this number 3.0 is devoted to basic biology, physiology, and nutrition; 5.1 to insecticidal and cultural control; 5.4 to insecticide residue determinations; 3.6 to biological control; 2.8 to insect sterility, attractants and other new approaches to control; 2.2 to evaluation of equipment for insect detection and control; 1.7 to varietal evaluation for insect resistance; 1.7 to insect vectors of diseases; and 1.3 to program leadership. The Walla Walla, Wash., station was closed in October 1962 and the funds and personnel transferred to Yakima, Wash., where increased emphasis will be given to the study of pea aphid control by sustained releases of reared parasites.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Cabbage Looper and Other Lepidopterous Pests of Vegetables. At Mesa, Ariz., studies were initiated in May 1963 to determine the seasonal occurrence and abundance of adults of the cabbage looper, alfalfa looper, beet armyworm, yellow-striped armyworm and corn earworm. Seven blacklight traps placed in various locations in the east end of the Salt River Valley showed that flight peaks occurred during mid-May for all of these moths. They also showed the cabbage looper and beet armyworm moths to be the most numerous of the five species under observation. Lettuce, cole crops, and sugarbeets cannot be grown in this area without controlling these insects which are also important pests of cotton.

At Charleston, S.C., a semi-artificial medium composed of dried collard leaf, ascorbic acid, water, and microbe inhibitors was used successfully to rear cabbage loopers to the pupal stage. However, newly hatched loopers developed very slowly on the medium, requiring 19 days to reach the pupal stage. An entirely artificial diet was less promising in initial trials.

2. Drosophila. In studies during 1962 at Beltsville, Md., on possible control of drosophila in tomato fields by the sterile-male technique, 3.2 million drosophila flies were reared at a cost of six cents per thousand for the rearing medium and other materials. An apparatus was designed and

used during the 1962 season to separate the males from the females. The males, weighing about half as much as the females, rose higher in a column of air in the apparatus and were removed from the upper part of the column through a side tube. The final separation consisted of about 92% males and 8% females; the latter were mostly undersized individuals that rose with the males in the air column and were not separated on the differential weight basis.

3. Leaf Miners. Commercial greenhouse tomatoes in Ohio are being damaged by Liriomyza leaf miners. At Beltsville, Md., a species of leaf miner from local chrysanthemums was established on greenhouse tomatoes and also in experimental field plots of tomatoes where it caused damage until frost. Infestations maintained during the active season of 1962 on caged field tomatoes and pupae from the greenhouse placed in soil under debris in the same cages failed to survive the winter of 1962-3. Apparently this species cannot survive the cold winters of northern areas. Continued infestations depend upon survival in greenhouses or reinfestations from warmer areas. Evidence has been obtained that recent infestations on greenhouse chrysanthemums in Ohio originated from cuttings of chrysanthemum grown in California and Florida.

Studies at Beltsville, Md., and Charleston, S.C., indicated that the same leaf miner that damages greenhouse crops is responsible for damage to field tomatoes in South Carolina. In 1963 this leaf miner again was present in commercial plantings in coastal South Carolina. When other factors were comparable, fields set with Florida plants had higher infestations throughout the season than those set with homegrown plants. Four and a partial fifth generation of the insect apparently developed in fields set with imported plants. Insect parasites played an important role in reducing leaf miner populations, but many of these natural enemies were killed by insecticides applied for control of leaf miners and other insects.

4. Southern Potato Wireworm. Approximately 5 to 15% of the recently-transplanted tomato plants in 3 commercial plantings in coastal South Carolina were killed as a result of the tunneling of the larvae of this insect into stalks of the plants. This is the first known report of such injury to tomato by this insect.

In South Carolina close examination of the southern potato wireworm showed that in the pupal stage the females have two protruding buds on the ventral side of the last abdominal segment and the males three such buds. The accuracy of sexing pupae by use of these characters was determined by study of the emerging adults. Accurate sex identifications of the pupae are needed in current studies of mating habits and effects of chemosterilants on the insect. In the past, only the sexes of adults could be distinguished and then by undesirable methods. Pressing out genitalia injures the adults. Administering carbon dioxide will cause the genitalia to be protruded but no fertile eggs have been obtained from females so treated.

5. Beet Leafhopper. The beet leafhopper population in desert and range breeding areas of southern Idaho in the spring and early summer of 1963 was one of the lowest on record. The overwintered adult population ranged from low to moderate in various areas, and unusually rainy weather during the period when the spring brood was hatching apparently decimated the nymphs of this generation.

6. Pea Aphid. The results of a 15-year study at Walla Walla, Wash., on the ecology of the pea aphid in relation to its role in the spread of a complex of mosaic diseases of peas were prepared for publication in a USDA technical bulletin, now in press. These studies yielded basic information on the seasonal biology and movements and natural enemies of this aphid that are proving valuable in the development of control measures.

7. Banded Cucumber Beetle. Limited information concerning the length of life stages, the relative value of several materials as larval food, and other phases of biology of the insect, was obtained in South Carolina. Only 5% of the males and 1% of the females under observation in cages survived a minimum outdoor temperature of 8° F. in December 1962. Larvae died when subjected to 0° F. but survived being submerged in water at room temperature for several days. A nematode that apparently is an important natural enemy of the larvae was identified as a new species in the genus *Ampimeris*.

8. Sweetpotato Insects. The following insects were found in one or more of 14 sweetpotato plantings in eastern South Carolina in 1962: Banded cucumber beetle, southern potato wireworm, sweetpotato flea beetle, elongate flea beetle, tortoise beetles, spotted cucumber beetle, and the tobacco flea beetle (only in plantings near tobacco fields). Most of the injury to the roots apparently was caused by the southern potato wireworm. The appearance of injury to the roots by larvae of certain of these insects in cage studies at Charleston, S.C., was as follows: Southern potato wireworm injury consisted of fairly small irregular-shaped holes seldom more than 1/2 inch deep. Injury by the banded cucumber beetle, the spotted cucumber beetle, the elongate flea beetle, and the pale-striped flea beetle, was similar to that caused by the wireworm and consisted of small round holes through the skin and enlarged cavities just under the skin. The flea beetles tunneled into the roots much more often than the cucumber beetles, which seldom tunneled. Sweetpotato flea beetle larvae tunneled just beneath the epidermis of the roots, producing winding mines. In harvested roots these mines usually appeared as shallow, winding channels in the skin. Cucumber beetle adults fed on the leaves of sweetpotatoes producing irregular holes similar to those caused by tortoise beetles. Elongate flea beetle adults fed on the upper surface of sweetpotato foliage producing characteristic winding paths. Pale-striped flea beetle adults ate small ragged holes in the leaves. Adults of the sweetpotato flea beetle ate narrow channels along the veins on the upper surface of the leaves.

Sweetpotato roots showing extensive injury of the type caused by the sweetpotato flea beetle were received from Wicomico County, Maryland, in 1962. Photographs were received of the same type of injury in Georgia. Similar feeding was noted in Louisiana and reports of such in North Carolina and Mississippi were received. Adults of what apparently is the flea beetle, Systema blanda, were taken in sweetpotato fields in Louisiana, and adults of another flea beetle, S. frontalis, in South Carolina.

9. Spider-Mite Nutrition. In Maryland studies, cross sections of bean leaf tissue showed marked differences in shape, arrangement and size of epidermal, palisade and spongy parenchyma cells associated with host plant nitrogen supply. The greatest differences and irregularities in leaf tissue appeared when plants were supplied low levels of nitrogen. Two-spotted spider mites produced more progeny concurrent with increased host plant nitrogen supply and absorption. The greatest proportional increase in mite fecundity concurred with the changes in irregularities in the leaf tissue associated with increases in total leaf nitrogen. Although little is known concerning the effect of leaf changes on mite feeding, this factor may contribute directly or indirectly to the increase in mite fecundity.

The susceptibility of resistant and non-resistant two-spotted spider mites to malathion increased when the host plants were supplied high nitrogen, 756 p.p.m. in nutrient solution rather than 252 p.p.m. When the same strains of mites were reared on host plants supplied high phosphorus, 400 p.p.m. as compared with 100 p.p.m., the resistant mites became more susceptible but the non-resistant mites became less susceptible.

Female two-spotted spider mites produced increasing numbers of eggs according to the nitrogen supply when fed on lima bean plants growing in quartz sand and supplied nutrient solutions containing nitrogen at levels varying from 28 to 784 p.p.m.

B. Insecticidal and Cultural Control

1. Corn Earworm on Sweet Corn. Of six insecticides evaluated for control of the corn earworm at Tifton, Ga., Bayer 41831 at 2 pounds per acre, Bayer 44646 at 1 pound per acre, Bayer 47940 at 2 pounds per acre, Zectran at 1 pound per acre, and Telodrin at 1 pound per acre, gave control equal to or better than that obtained with a 1-pound-per-acre application of a DDT standard. Dimethoate, Zinophos, and heptachlor at 1 pound per acre gave poorer control than the DDT standard.

2. Beet Leafhopper-Curly Top on Tomato. In experiments in Utah various phosphorus insecticides showed promise in the control of the beet leafhopper on tomato and in the prevention of the spread of the virus of curly top disease to tomato. For example, in one experiment, curly top was reduced 40% by 4 applications of dimethoate, one in the starter solutions and 3 to the foliage at 2-week intervals. Similar results have been

obtained with phorate and Phosdrin. The work will need to be continued to develop a safe control program that can be depended upon for effectiveness and that can be recommended to growers.

3. Beet Leafhopper Control on Cantaloups. Field-plot experiments were conducted at Mesa, Ariz., for the control of the beet leafhopper and prevention of curly top in cantaloups. Previous experiments indicated that phorate as granules under the seed or as a foliage spray was effective against the leafhopper, and these treatments were used in this experiment. One, two, and three infestations of curly-top infective leafhoppers were effected by caging the insects on pretreated plants for 48 hours. Granules under the seed followed by one foliage spray on 2-leaf plants reduced losses in yield when plants were exposed twice to curly top-infective leafhoppers. Granules under the seed followed by two foliage sprays (one on 2-leaf plants and one on 4-leaf plants) reduced losses in yield when plants were exposed three times to curly top-infective leafhoppers, but under the conditions of this experiment granules under the seed without foliage sprays were ineffective. Multiple exposures to curly top-infective leafhoppers damaged plants and reduced yields more than one infestation in any stage of development. Small-plot experiments are currently under way in which a population of beet leafhoppers with a known percent of curly top-infective individuals has been retained on variously treated cantaloups from the early 2-leaf stage to the 6-leaf stage of plant development. This was done by caging entire plots and introducing the leafhoppers. Some of the plots contained favorable host plants in addition to the cantaloups, others did not. Effect on the plants and yield of melons are being determined.

4. Beet Leafhopper on Beans. Laboratory and field tests are being continued in an effort to find a control of curly top on beans by controlling the vector. The addition of beet juice or sugar to systemic insecticides of phorate, Phosdrin, or dimethoate has speeded up the mortality of leafhoppers and also reduced the amount of curly top over that obtained by the use of the insecticides alone. These results were obtained when the bean plants were infested with beet leafhoppers the day after they were sprayed. An effort is being made to determine how long the materials are effective. Many other materials are being screened in an effort to find a practical control of curly top on beans by controlling the vector.

5. Western Bean Cutworm. The western bean cutworm is one of the most threatening insect pests to the 125,000 acres of beans grown in southcentral Idaho. DDT gives very good control but may cause residues in meat or milk from drifting to pasture and hay crops growing in the same area. In an effort to find a less objectionable material, cutworm larvae reared in the laboratory from adult moths collected in blacklight traps were used in screening tests. Of many materials tested thus far, carbaryl, Zectran, Dylox, Perthane, endosulfan, carbophenothion, EPN, methyl ethyl Guthion, malathion, diazinon, and Bayer 25141 look the most promising.

6. Cowpea Curculio on Southern Peas. In field plot tests in South Carolina, dieldrin in granules showed the most promise, but was not significantly better than sprays of endosulfan, the currently recommended insecticide, or toxaphene or than a soil application of endosulfan in granules. A single soil application of toxaphene in granules was inferior.

7. Bean Insects. In large scale field tests in California on lima beans, carbaryl, toxaphene plus demeton, and dimethoate alone, gave the best control of lygus bug nymphs and greatest reduction in injury. Dylox, carbaryl, and Zectran, each in combination with demeton, also reduced nymph populations. Dimethoate showed promise against thrips. Carbaryl plus demeton and diazinon were the most effective against the two-spotted spider mite. In reducing injury to pods due to pod borer, carbaryl, endosulfan, and toxaphene were the most effective. In these experiments 28 of the most promising materials were tested. No control of the lima bean pod borer was obtained with dust mixtures containing pyrenone or pyrethrum and Bacillus thuringiensis. A carbaryl spray was the most effective.

A summary of 3-years' data on the effect of time of planting beans on pod borer infestations showed that in most years it is possible to reduce pod injury due to pod borer by planting beans between April 1 and May 1.

Of 18 experimental materials tested at Beltsville, Md., against the Mexican bean beetle, several gave promising results, including dimethoate and DDVP, which are relatively safe to use.

8. Leaf Miners. Of 38 compounds compared in laboratory tests in South Carolina in the spring of 1963, two experimental materials were more effective than naled--the standard--and will be field tested. In field tests dimethoate in foliage spray and soil drench and Guthion in foliage spray gave excellent control of leaf miners on tomato plants. A parathion spray was only partially effective, diazinon spray and phorate granules and Di-syston granules applied to the soil around plants were of no value under the existing extremely dry soil conditions.

Greenhouse experiments at Beltsville showed that three applications at 6- to 7-day intervals of DDVP aerosols or sprays of Zectran or diazinon destroyed larvae and adults on tomato and virtually cleaned up infestations during the active season of 1962.

9. Banded Cucumber Beetle. Of 94 compounds compared in laboratory tests in South Carolina, eight experimental materials were as toxic to the larvae as parathion--the standard. It is too early to tell whether any will prove to be of practical use. Larvae reared from beetles collected at Arnaudville and Baton Rouge, La., and Charleston, S.C., were about equally susceptible to aldrin, DDT, and Telodrin

In field tests at Baton Rouge, La., endosulfan spray and Telodrin granules gave promising results in the control of banded cucumber beetle larvae

feeding on the edible roots of sweetpotato. Telodrin also controlled the sweetpotato weevil in these tests. Neither insecticide is available for commercial use on sweetpotato. Surveys showed the numbers of banded cucumber beetle adults in sweetpotato fields did not correlate with damage to sweetpotato roots by larvae of these beetles. This lack of correlation may have been due to predators feeding on beetle eggs and to the fact that predators were less numerous in or near fields previously treated with persistent insecticides, such as heptachlor.

10. Banded Cucumber Beetle and Southern Potato Wireworm on Sweetpotatoes. In one 1962 experiment in South Carolina, in which injury was attributed to larvae of the southern potato wireworm and the banded cucumber beetle, DDT at 20 pounds per acre gave good control and was more effective than Telodrin at 1 pound or parathion at 6 pounds. None of these treatments caused any measurable effect on yields. In another experiment, DDT at 20 pounds per acre prevented injury by the southern potato wireworm. Parathion at 5 pounds and aldrin at 2 pounds per acre were ineffective. The failure of parathion is attributed to lack of adequate persistence to protect sweetpotatoes throughout the long growing season.

11. Squash Insects. Each compound tested in field plots in South Carolina gave adequate control of a light infestation of the pickleworm on yellow summer squash. The squash vine borer population was too low to give significant data, even though a count of eggs on the plants indicated that a good infestation should have occurred. In control of the melon aphid, Zectran and naled were superior to all other materials tested, but carbaryl, Bayer 44646, and lindane gave adequate control.

12. Aphids on Cabbage. Demeton, Di-syston, Phosdrin, phosphamidon, and dimethoate were the most effective materials tested in field plots in South Carolina for control of the cabbage aphid. These materials were superior to endosulfan, phorate, and a pyrethrum extract against that insect. Di-syston and phorate were superior to demeton and dimethoate in control of a root aphid, Pemphigus sp., which apparently did not harm the cabbage plants in the field under observation.

13. Cabbage Caterpillars. In South Carolina 17 experimental insecticides were highly toxic to the cabbage looper among 73 new compounds screen-tested in the laboratory. None were satisfactory in field tests although several, including Zectran, Bayer 44646, and Bayer 41831, gave good control of the cabbage looper and the fall armyworm. The experimental materials are either too toxic to warm-blooded animals to be of much promise or damage the plants. Continued studies will be necessary to develop satisfactory insecticides for use on cabbage and related crops within the last month before harvest.

A South Carolina strain of the cabbage looper proved less susceptible in laboratory tests than did a New York strain to naled, DDT, endrin, and parathion.

At Mesa, Ariz., field-plot tests showed that for use up to beginning of head formation, the following sprays gave good control of the cabbage looper: Toxaphene + DDT, Zectran, endosulfan, and American Cyanamid experimental compounds 43064 and 47031. A dust mixture of carbaryl with endosulfan also gave good looper control. For late use after the heads begin to form promising results were obtained with naled and American Cyanamid 43064 and 47031 sprays and with pyrethrum or pyrethrum + piperonyl butoxide dusts. Beet armyworms were harder to kill, and several of the newer materials gave better results than the standard toxaphene + DDT. These included Zectran and American Cyanamid 47031 sprays and the carbaryl + endosulfan dust mixture, although endosulfan alone was inferior.

In southern California 12 of the most promising experimental insecticides for cabbage looper control were tested in field plots with no outstanding control. Also, 7 different systemic insecticides including phorate, D-syston, and dimethoate, were ineffective when applied as a sidedressing 5 inches to one side of each row.

14. Aphid Control in Cold Weather. Experiments in California on 7 leafy vegetables showed that at temperatures below 70° F., dimethoate and Isolan were more effective against aphids than parathion and other materials now recommended. In these tests parathion, endosulfan, naled, Guthion, and methyl Guthion did not give satisfactory control of the cabbage aphid and green peach aphid when temperatures remained below 70° F. Also, there was a tendency for residues of the phosphorus materials to persist much longer on the foliage than at higher temperatures. These results showed that growers in the winter who follow normal insecticide programs developed for warm weather may not only fail to control aphids but may also cause their crops to be contaminated at harvesttime with excess residues of insecticides. Special programs need to be developed for aphid control on winter vegetables during cold weather. These results in California were supported by similar results in field tests with parathion on lettuce in Arizona and on kale in Maryland.

C. Insecticide Residue Determinations

1. Minimum Waiting Periods. To obtain residue data needed to establish minimum waiting periods from the last application of insecticides on vegetables until harvest, and to form a basis for the development of safe insecticide dosages and application programs, numerous samples of vegetables from experimental plots at Riverside, Calif.; Mesa, Ariz.; Logan, Utah; Yakima, Wash.; Charleston, S.C.; Tifton, Ga.; and Beltsville, Md., were analyzed by chemists at Yakima, Wash.; Tifton, Ga.; and Beltsville, Md., and by various insecticide companies. Samples from 10 different crops from Riverside, for example, were analyzed at Yakima for residues of 6 different insecticides and the results correlated with various factors, such as temperature, rainfall, dosage, and the time interval from application to harvest. The results of these studies have been of great value in the development of recommendations of safe and effective uses of insecticides.

During the past year residue studies have led to the general revision of the USDA recommendations relative to the use of parathion on winter vegetables such as celery, cabbage, broccoli, and related crops to take into account the greatly increased persistence of parathion residues at temperatures below 70° F. The revised recommendations are given in USDA Agriculture Handbook No. 120 "Insecticide Recommendations of the Entomology Research Division for the Control of Insects Attacking Crops and Livestock for 1963."

2. Telodrin. At Tifton, Ga., sweet corn treated with 0.5 to 2 lb. of Telodrin per acre was analyzed. Initial residue deposits on leaf and stalk samples ranged from 1.9 to 8.4 p.p.m. but decreased rapidly after 24 hours. The maximum after 21 days was 0.7 p.p.m. Initial residues on the husks ranged from 1.8 p.p.m. to 2.0 p.p.m. Only the 2 lb.-per-acre level showed any material (0.01 p.p.m.) on kernels and cob and none could be detected 24 hours after application.

3. Phorate Residues in Seedling Cantaloup Plants Affected by Placement in Soil. Field plot experiments were conducted at Mesa, Ariz., to determine the most effective placement of phorate granules with respect to the seed in the control of the beet leafhopper on cantaloup. Plants grown in plots receiving various granular placements were harvested in the 2-leaf stage and submitted for phorate analysis. The greatest amount of phorate was recovered from granules intermixed with the seed, but this treatment was unsatisfactory because of a reduction in plant stand. The next greatest recovery of phorate was from the placement of granules 2 inches below the seed. Significantly less amounts of phorate were recovered from the placement of granules 1 inch below the seed, one-half inch below, and 1 inch below the seed and 2 inches toward the water furrow.

4. DDVP Residues. In Maryland DDVP residues on greenhouse tomato fruits decreased from a range of 0.5 to 1.3 p.p.m. on ripe fruits harvested one hour after treatment with DDVP aerosol to none on ripe fruits harvested 5 days later. On lettuce foliage the residues ranged from 1.4 to 2.5 p.p.m. after 1 hour and were 0.2 after 5 days. The treatments were effective against aphids, whiteflies, spider mites, cabbage loopers, and leaf miners.

5. Temperature Affects Disappearance of Parathion Residues. In Maryland, the laboratory study on the effect of temperature on the rate of disappearance of parathion residues was continued. Beans were grown in controlled temperature chambers and variables other than temperature were eliminated as completely as possible. A measured amount of parathion was applied in emulsion form to each leaf to insure uniform amounts at the beginning of the experiment. One hour after application the deposits present were about 700 to 800 micrograms of parathion per leaf. At 50° C. this decreased to about 570 micrograms per leaf after 3 days and 100 after 21 days. At 70° C. the parathion decreased to 236 micrograms after 3 days and 7 micrograms after 21 days.

D. Biological Control

1. Cabbage Looper and Other Caterpillars on Cole Crops. In further studies in South Carolina, the pathogen Bacillus thuringiensis gave excellent control in field plots of the imported cabbageworm and diamondback moth on cabbage and partial control of the cabbage looper and fall armyworm. The addition of corn oil again tended to increase the kill of caterpillars given by the pathogen. Even though the Bacillus did not give as high reduction of the looper population as did parathion and naled, which are currently recommended for control of the looper on cabbage, the pathogen was as effective as these insecticides in preventing damage to the plants by the insect. The pathogen acts as a repellent to feeding by the caterpillars, as well as being toxic to them. Even though B. thuringiensis proved as effective as parathion and naled in preventing injury by the cabbage looper in 1963 spring-season tests, six weekly applications of these materials did not give adequate control of that insect. A new commercial suspension formulation of B. thuringiensis, known as Thuricide 90T, did not prove any more effective against the cabbage looper in laboratory and field tests in 1963 than did the most promising of previously available wettable powder formulations of the pathogen. Two commercial formulations of B. thuringiensis gave faster kill of a laboratory-reared New York strain of the cabbage looper than of a Charleston, S.C., strain. Fifty-seven percent of third-instar loopers were killed in 72 hours after having fed on collard foliage that had been dipped in a concentrated suspension of parasporal crystals of B. thuringiensis (G2), furnished by the Insect Pathology Laboratory, Beltsville, Md. Two dilutions of ultraviolet irradiated parasporal crystals furnished by the Laboratory were apparently not pathogenic to third-instar cabbage looper larvae in laboratory cages.

Laboratory tests in South Carolina during 1962 and 1963 indicated that a Charleston, S.C., culture of a nuclear polyhedrosis virus was more toxic to Charleston cabbage looper larvae than cultures from California, New York, Texas, and Virginia. A combination of the Charleston virus culture and Thuricide 90T, a newly-introduced commercial suspension formulation of the pathogen Bacillus thuringiensis, was as effective against the cabbage looper as parathion in 1963 field tests. The pathogen combination gave adequate control when applied 12 times at intervals of 3 or 4 days, but not quite adequate when used weekly. The virus culture lost its toxicity to cabbage loopers much more rapidly when exposed to outdoor weathering than when kept indoors.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Sex Lure in Banded Cucumber Beetle. A natural sex attractant produced by females of this insect, usually by the time they were 10 days old, was demonstrated in South Carolina to be capable of luring males of the species from distances up to 49 feet. Unmated females remained attractive to males as long as 79 days. Most females ceased to be attractive after one mating, and none were attractive after two matings. The attractant was extracted

from female abdomens with alcohol. Extracts of the heads and thoraces and of filter paper on which females had crawled gave negative results.

2. Sterilization of Banded Cucumber Beetle. In laboratory cage studies, virgin males and females of this beetle, approximately 5 days old, were mated after having fed on collard foliage which was dipped in metepa solutions (in 0.05% Triton X-100) at concentrations of 0.1, 0.2, and 0.5%. Virgin males and females were also fed on foliage dipped in the 0.2% metepa solution and then mated with untreated virgin females and males. The insects were allowed to feed on the treated foliage for 48 hours, and then on untreated foliage for 30 days. Ninety to 100% of the eggs obtained from treated females mated to treated males failed to hatch. The three concentrations were about equal in effectiveness. Males were more effectively sterilized than females. Only 10% of the eggs laid by untreated females mated to treated males hatched; whereas, 90% of the eggs laid by treated females mated to untreated males hatched. In another test virgin males approximately 3 days old were dipped in a 1.0% metepa solution and mated with virgin females. Only 4% of the eggs deposited by these females hatched.

3. Winter Survival of Sterilized Mexican Bean Beetle. In experiments at Beltsville adult males and females maturing in September and early October were dipped in 0.25 or 0.5% apholate, marked with enamel paints for identification, and placed in hibernating cages with untreated beetles. Winter survival and spring emergence of beetles in all three groups were similar (about 15%). This treatment had been shown in laboratory tests to render the beetles sterile.

4. Sterilization of Cabbage Looper. In studies of the sterile-male technique at Riverside, Calif., the cabbage looper males were sterilized by exposure to glass that had been sprayed with an 8% tepa solution. The spray residue on the inside surface of glass jars in the laboratory were effective for 18 days. Exposure of males to freshly dried residues for 5 minutes resulted in 16% sterile eggs, while a 45-minute exposure gave 93% sterile eggs and a 2-hour exposure gave complete sterility. Residues from 16% metepa gave similar results. Promising results were obtained in the self-sterilization of the looper moths by attracting them to blacklight bulbs surrounded by a celluloid shield coated with residues from 8% tepa solution. In a walk-in cage containing four 20-foot rows of cabbage infested with 30 pairs of 1-day-old moths 95% fewer larvae were produced than in similar cages equipped with lights without tepa.

5. Sterilization of Drosophila. In Maryland studies, complete sterility of Drosophila melanogaster eggs resulted when virgin females were mated with newly emerged males that had fed for 20 hours on freshly-prepared sugar-yeast bait containing 1% apholate. However, only partial sterility resulted when virgin females were mated with males that had fed for the same period on sugar-yeast-apholate bait that had aged 1 to 5 days. The percentages of emergence of adults from eggs laid in these pairings were 22 for 1-day-old

baits, 31 for 3-day-old baits, and 40 for 5-day-old baits, compared with 71 for checks where the males received no apholate.

Male D. melanogaster mated less readily and less frequently immediately after exposure to 16 kr of gamma radiation than did untreated males. The period prior to first copulation for irradiated (16 kr) males was over 3 times that of untreated males for the first mating, and over 5 times the precopulation period of untreated males before the second mating. A 24-hour recovery period after exposure to 16 kr resulted in normal mating behavior and frequency. After this recovery period, there was little effect on mating competitiveness based on tests where irradiated (16 kr) males and untreated males were confined in ratios of 1:1, 5:1, 10:1, and 20:1.

F. Evaluation of Equipment for Insect Detection and Control

1. Electrostatic Duster. Studies conducted in cooperation with ARS agricultural engineers at Tifton, Ga., indicated that plants dusted by use of an electrostatic duster that produced either positive or negative charges on the particles, had about 57% and 36%, respectively, greater residues than plants dusted with uncharged particles, even 48 hours after application. The positively charged treatment appeared to be slightly better than the negatively charged treatment during the same period.

2. Improvement of Corn Earworm Control Methods. Agricultural engineers and entomologists at Tifton, Ga., found that superior spray coverage and corn earworm control on sweet corn could be obtained when sprays were applied at 100 p.s.i. with fan type nozzles placed 90° to the plant. Methylene blue was a satisfactory dye indicator to study spray residue deposits.

3. USDA Developed Sprayer Now in Commerical Production. A commercial version of the USDA trailing boom sprayer developed at Forest Grove, Oreg., by engineers of the Agricultural Engineering Research Division, in cooperation with the entomologists, is now being manufactured by Rear's Manufacturing Company, 755 River Road, Eugene, Oreg., as a Pul-Tank trailing boom spraying unit. It is trailer-mounted with a ground clearance of 30 inches and is made in 6- and 8-row models. A short coupling device on the Pul-Tank trailer allows it to follow the tractor tracks and permits short turns at the headlands of a field. The trailing booms are lifted by partially rotating the draw boom. As the draw boom is rotated, the outer portions are lifted up and fold upright, all by means of a hydraulic cylinder and cable arrangement. The Pul-Tank has a capacity of 300 gallons. The spray pump is driven by power take-off from the tractor. Each row is covered by 5 cone-type spray nozzles. This commercial unit proved exceptionally useful to Oregon broccoli growers in the control of cabbage caterpillars and aphids in 1962.

4. Increased Power of Airplane Sprayer Changes Spray Pattern. When the Rawdon T-1 at Forest Grove, Oreg., was equipped with a 150 hp., engine, a non-symmetrical nozzle arrangement did not improve the uniformity of the

spray deposit across the treated swath over that obtained with a symmetrical arrangement. However, since the installation of a 250 hp., engine in this airplane, there is a noticeable difference in the shape of spray deposit patterns from the asymmetrical and symmetrical nozzle arrangements. The symmetrical arrangement produced a pattern triangular in shape, while the non-symmetrical arrangement produced a more trapezoidal shaped curve. The non-symmetrical arrangement also left a typical low deposit area near the swath center while the symmetrical arrangement did not have this low deposit area. This work was in cooperation with the Agricultural Engineering Research Division.

5. Application of Insecticides with Ground Equipment. In exploratory field-plot tests in South Carolina in which only one application was made of each insecticide, no significant difference in cabbage looper and diamondback moth reduction was found between toxaphene (at 2.5 lb./a.) and naled (at 2 lb./a.) applied either with a 5-nozzle per row trailing boom or 3- and 5-nozzle per row conventional booms. Neither were any significant differences in caterpillar control obtained from application of the two insecticides in 10, 20, and 100 gallons of water per acre, applied with different types of booms. There were tendencies for the 20 and 100 gallonages applied with 5-nozzle booms to be most effective. The trailing booms used were designed by USDA agricultural engineers at Forest Grove, Oreg., and manufactured there under their supervision.

G. Varietal Evaluation for Insect Control

1. Corn Earworm and Fall Armyworm on Sweet Corn. At Tifton, Ga., irradiation trials were unsuccessful in producing corn mutagens with increased earworm resistance. Earworm resistance varied with planting date even under the same infestation level. Ear penetration by earworm larvae varied significantly with the time of infestation after pollination. Preliminary tests indicated no differences in oviposition response in relation to the color of the corn silks. Bioassay of extractions of freshly harvested plant material have indicated that differences exist among inbreds, in leaf tissue susceptibility to fall armyworm feeding, and in antibiosis of silks to corn earworm larvae. Inbreds with foliage resistance against the fall armyworm do not necessarily have resistance against the corn earworm.

At West Lafayette, Ind., 404 entries of experimental sweet corn hybrids were rated for earworm resistance. The hybrid 363-1-1 X 379-1-1 was not damaged and was rated as being the most resistant and promising source of resistant germ plasm. Several other hybrids were rated as extremely resistant. Earworm larvae were able to mature on the silks alone on several hybrids and seldom reached the tip or kernels of the ears. Inbred 259(13) 1-2-1-1-2-1-1-1-1-1-1, one of 19 white sweet corn inbreds tested, was very resistant to corn earworm but had poor quality. Of 86 yellow sweet corn inbreds tested, 390(9)2-1-3-1 was rated as the most resistant. This inbred has shown good resistance in the past and transmits resistance to its progeny. Twenty-one other yellow inbreds were rated as resistant to the corn earworm.

2. Southern Potato Wireworm on Sweetpotatoes. Sweetpotato breeding Line L3-64 in South Carolina was the least susceptible to injury by larvae of this insect in field trials of several lines. Line L3-64 also showed considerable resistance to banded cucumber beetle injury in Louisiana.

H. Insect Vectors of Diseases

1. Aphid Control and Its Relation to Lettuce Mosaic Virus. At Mesa, Ariz., good control of the green peach aphid in lettuce was obtained in experimental plots with phorate granules one-half inch and 2 inches under the seed. Dimethoate sprays on young plants also gave good control, but winged aphids from an adjacent older lettuce planting eventually infected the entire experimental planting with mosaic. However, a significantly heavier yield of lettuce was obtained from treated plots than from the untreated check, even though symptoms of disease did appear in the treated areas.

2. Aphids Correlated with Mosaic in Lettuce Fields. Thirteen lettuce fields in the Salt River Valley of Arizona were studied to determine aphid populations and the resulting crop loss from lettuce mosaic. Losses in yield from lettuce mosaic varied from 2.2% up to 21.2%. Early plantings showed less damage than later ones. Fields with very few or no aphids until after the plants had 10 or more leaves had little mosaic at harvesttime. No correlation was found between the presence of weeds and lettuce mosaic.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Basic Biology, Physiology and Nutrition

Henneberry, T. J., and Smith, Floyd F. 1962. The effect of plant nutrition on the fecundity and susceptibility to malathion of two strains of two-spotted spider mite. Proc. 11th Intern.Ent. Cong.: 49-53.

Henneberry, T. J. 1962. The effect of host plant nitrogen supply and age of leaf tissue on the fecundity of the two-spotted spider mite. Jour. Econ. Ent. 55: 617-8.

Henneberry, T. J. 1963. Effects of gamma radiation on the fertility and longevity of Drosophila melanogaster. Jour. Econ. Ent. 56: 279-81.

Wallis, R. L. 1962. Spring migration of the six-spotted leafhopper in the Western Great Plains. Jour. Econ. Ent. 55: 871-4.

Wallis, R. L. 1962. Host plant preference of the six-spotted leafhopper. Jour. Econ. Ent. 55: 998-9.

Wave, H. E. 1962. Seasonal distribution of drosophilid flies in Beltsville, Maryland, tomato fields. Jour. Econ. Ent. 55: 409-11.

Insecticidal and Cultural Control

Agric. Res. Serv. and Fed. Ext. Serv. 1963. Insecticide recommendations of the Entomology Research Division for the control of insects attacking crops and livestock for 1963. USDA Agriculture Handbook No. 120 (Revised).

Boswell, Victor R., and Reed, L. B. 1962. Okra culture. USDA Leaflet No. 449: 1-8. (Revised).

Crops Res. Div. and Ent. Res. Div. 1963. Growing pumpkins and squashes. USDA Farmers' Bulletin No. 2086: 1-27. (Revised).

Doolittle, S. P., Taylor, A. L., Danielson, L. L., and Reed, L. B. 1962. Commercial watermelon growing. USDA Agriculture Information Bulletin No. 259: 1-31.

Fulton, R. A., Smith, Floyd F., and Busbey, Ruth L. 1962. Respiratory devices for protection against certain pesticides. USDA ARS 33-76: 1-15, and Suppl. 1, 1963: 1-4.

Gibson, Kenneth E., and Fallini, Joe T. 1963. Beet leafhopper control in southern Idaho by seeding breeding areas to range grass. USDA ARS 33-83: 1-5.

- Mason, Horatio C., and Dorst, Howard E. 1962. Controlling drosophila flies on tomatoes grown for canning. USDA Farmers' Bulletin No. 2189: 1-12.
- Porte, William S., and Wilcox, J. 1963. Commercial production of tomatoes. USDA Farmers' Bulletin No. 2045: 1-48. (Revised).
- Reed, L. B., and Doolittle, S. P. 1963. Insects and diseases of vegetables in the home garden. USDA Home and Garden Bulletin No. 46: 1-48. (Revised).
- Reid, W. J., Jr., and Cuthbert, F. P., Jr. 1963. Cabbage insects: How to control them in the home garden. USDA Home and Garden Bulletin No. 44: 1-7. (Revised).
- Shriver, David, and Henneberry, T. J. 1962. Acaricidal properties of Aramite and Kelthane against two strains of two-spotted spider mite. Jour. Econ. Ent. 55: 799-800.
- Smith, Floyd F., Fulton, R. A., and Boswell, A. L. 1963. Some variations in response of two-spotted spider mite to acaricides. Jour. Econ. Ent. 56: 224-7.
- Wester, R. E., and Smith, Floyd F. 1962. Systemic insecticides for Mexican bean beetle control. Agric. Chem. 17: 44-6, 103.
- Wilcox, J., and Howland, A. F. 1963. The tomato fruitworm: How to control it. USDA Leaflet No. 367: 1-5. (Revised).

Insecticide Residue Determinations

- Cook, W. C., Butler, L., Walker, K. C., and Featherston, P. S. 1963. Granular in-furrow treatments with phorate and Di-syston against the pea aphid on peas. Jour. Econ. Ent. 56: 95-8.

Biological Control

- Smith, Floyd F., Henneberry, T. J., and Boswell, A. L. 1963. The pesticide tolerance of Typhlodromus fallacis (Garman) and Phytoseiulus persimilis A.H. with some observations on the predator efficiency of P. persimilis. Jour. Econ. Ent. 56: 274-8.

Insect Sterility, Attractants and Other New Approaches to Control

- Beroza, M., and Green, N. 1963. Materials tested as insect attractants. USDA Agriculture Handbook No. 239: 1-148.

Evaluation of Equipment for Insect Detection and Control

Deonier, Calvin E., Getzendaner, C. W., Young, V. D., and Winterfield, Robert G. 1963. Mylar plastic tags for sampling spray deposition on individual leaves and surfaces. Jour. Econ. Ent. 56: 114-5.

Insect Vectors of Diseases

Coudriet, D. L. 1962. Efficiency of various insects as vectors of cucumber mosaic and watermelon mosaic viruses in cantaloups. Jour. Econ. Ent. 55: 519-20.

Kahn, Robert, Scott, Howard A., Smith, Floyd F., and Higgins, J. J. 1963. Sunn hemp yellow mosaic incited by the bean yellow mosaic virus. Plant Dis. Rept. 47: 364-8.

Smith, Floyd F., and Brierley, Philip. 1962. Some insect and mite injuries resembling plant virus symptoms. Proc. 11th Intern. Ent. Cong: 49-53.

CROP PEST CONTROL TECHNIQUES AND EQUIPMENT

Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. In many situations, effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the states mentioned, unless otherwise noted. At Wooster, Ohio, basic research is conducted on fundamental studies of aerosols and on various spray formation devices. Soil fumigation research also is conducted at Wooster, Ohio. Chemical insect and disease control research is conducted at the new Grain Insects Research Laboratory at Tifton, Georgia, chiefly on corn insects; at Ames, Iowa, particularly for corn borer control; and at Wooster, Ohio, on improved equipment for corn borer control. Disease control research is also conducted at Wooster, Ohio. Aircraft application equipment is studied at Beltsville, Maryland, in cooperation with the Forest Service; and at Forest Grove, Oregon, in cooperation with the Oregon and Washington Stations, on low growing crops. Pest control equipment research is conducted for vegetable crops at Forest Grove, Oregon.

The Federal scientific effort devoted to research in this area totals 13.6 professional man-years per year. Of this number, 0.7 is devoted to soil fumigation; 0.9 to pest control by ground equipment; 0.6 to aircraft equipment.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Basic Studies in Aerosols and Spray Formation

Fungicide sprays of copper were applied at ten-day intervals to seven vegetables (collards, eggplant, lima beans, peppers, tomatoes, cucumbers and potatoes). Spray volume, drop size, and formulation were the controlled variables. The vegetables were selected for their different leaf characters and growth form. Neither the initial nor weathered deposits of copper applied in sprays of different drop size appeared to differ from each other by a significant amount. As would be expected, pubescent foliage appeared to retain more copper initially as well as after weathering. The low-gallonage application rates gave the best fungicide retention, and a spreader-sticker apparently increased initial runoff thereby reducing the initial copper deposit. An addition of oil increased copper adhesion on all seven types of foliage.

Sugar beets sprayed on a similar schedule indicated a relation between copper adhesion on the foliage and the amount of viscosity of oil used. Increasing either of these two factors decreased the amount of weathering taking place between spray applications.

Soil Fumigation.

1. The study and development of methods and equipment for controlling crop pests by the application of chemicals to soil was conducted in Ohio. The crops treated included over a dozen kinds of vegetables, potatoes, and sugar beets. Sour cherry trees were treated, and sycamore and white pine trees were treated for use in reforestation or strip mine reclamation. Pest control was attempted on diseases including potato scab, onion smut, pythium (damping off) and verticillium wilt; weed control was attempted by treating the seeds of nut grass, purslane, ragweed and smartweed; insect control was attempted on miscellaneous soil inhabiting root feeders, wire worms, and grubs; and nematode control was attempted.

Rotary tiller equipment was used for applying non-volatile materials requiring thorough mixing into the soil either in rows or over all treatments. The field cultivator with injector blades was used for more volatile materials injected under pressure and for side dressing of rows of living plants. Specially prepared equipment attached to a planter was used to introduce insecticidal and fungicidal material into the seed zone of onions at planting time. It is desirable to introduce these materials near but not actually in contact with the seed. Excellent control of smut and maggots was obtained with some of the available pesticides using this equipment, with yield increases of as much as 40 percent over untreated plantings.

Equipment which places an impervious seal of polyethylene film over a soil treatment has been in use for some time. The use of emulsions of asphalt, wax, or latex is being investigated as a less expensive method

of surface sealing. Pressurized equipment for handling these viscous liquid seals has been used successfully. The nozzle producing the most satisfactory surface cover with these materials is a double flat spray type. Width of the sealed strip is controlled by vertical position of the nozzle. The axis of the two spray patterns are inclined from each other and to the soil surface so that one axis is inclined 18 degrees from vertical toward the direction of travel and the other is similarly inclined in the opposite direction. A more nearly complete and continuous coating of all soil particles is obtained by this application than from a pattern having a single vertical or inclined axis of approach to the soil surface.

Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

Research activities with ground equipment in Oregon consisted primarily of modifications to the U.S.D.A. row crop sprayer, making a series of applications for flea beetle and aphid control, and conducting spray penetration tests on broccoli with two general purpose air blast sprayers. Improvements were made to the row crop sprayer which consisted of changing the shut-off valves and plumbing lines and modifying the bracket for adjusting the top spray nozzles.

Spray penetration tests were conducted with a Mitchell general purpose air blast sprayer manufactured by Mitchell, Lewis & Staver, Portland, Oregon, having two 16-inch fans connected in tandem. The two fan shaped outlets showed air discharge rates of 1487 and 1591 cu. ft. per min., respectively, and a variation of air velocity within the outlet which varied between 5000 and 9700 ft. per min. This discharge rate is low and limits the maximum swath attainable. In one test using a 45-foot plot treated from two sides, the four middle rows did not receive measurable amounts of spray on the bottom leaf surface on one row side of the plant. The top sides of the sampled leaves of all 15 rows received deposit with rates in excess of two and one-half gallons per acre. The data also show that light winds often prevent spray being carried to and being deposited on some leaf surfaces more than 12 feet from the machine on the windward side.

An airblast orchard sprayer manufactured by the Rear Manufacturing Company, Eugene, Oregon, was tested to determine amount of leaf coverage obtained when using a 78-foot plot width and making applications from two sides of the plot. Two leaves per plant and one plant per row were sampled in each of the 27 rows of broccoli. Each leaf sampled had two top and two bottom sampling areas. The data show that 29 percent of the top leaf areas had deposit rates greater than 30 gallons per acre and no rate less than one and one-half gallons per acre. On the underleaf surfaces, only 13 percent of the sample areas received sprays at rates in excess of 30 gallons per acre and only three areas with rates less than one GPA. The Rear and Mitchell machines were not designed for field crop spraying and would need modifications in the outlet to adopt it for this use.

A series of insecticide applications for the control of flea beetles and aphids was made with the U.S.D.A. Row Crop sprayer in cooperation with the Oregon Station. Five insecticide foliage sprays and two fungicide sprays were applied to replicated plots which were .63 acres in size. The timing of the applications was based on insect counts and extended from July to September, inclusive. Three insecticides were used, namely, DDT at two pounds per acre, Sevin and Thidan at one pound per acre of toxicant. DDT and Sevin were superior to Thidan in holding adults to about two beetles per ten sweeps. Thiodan was outstanding for aphid control.

Studies on control of *Cercospora* leaf spot on sugar beets with sprays were conducted in cooperation with the Ohio Station. Comparative experiments were conducted using different fungicide formulations, timing of applications and number of applications made with boom and nozzle hydraulic sprayer. The use of oil with fixed copper fungicide and an emulsifying agent improved effectiveness in disease control but not as definitive as the previous year. Data obtained in 1961 indicated that a combination of fixed-copper fungicide and an emulsifiable spray oil was capable of good control of *Cercospora* leaf spot of sugar beets when sprays are applied at six 10-day intervals, beginning about July 20 and ending about September 10. However, most growers were interested in reducing the number of applications by lengthening the interval to 15 days. The use of oil with an emulsifying agent in 1962 improved the adhesion of copper fungicides so that there was no significant difference in disease control between 9, 12 and 15 day intervals of application. Maneb was more effective in disease control than copper.

Field experiments involving gallonage per acre, and pressure variations in spraying with an air-blast sprayer were made on sugar beets in northwestern Ohio. Six spray applications were made at 10-day intervals from July 21 to September 10 with a turntable type air sprayer with approximately 31,000 cu. ft. per min. The gallonage per acre was varied from 40 to 20 to 10 gallons per acre with pressure varied from 300 to 60 pounds per square inch. All application rates and pressures with the air-blast sprayer gave more effective control of disease than hydraulic spray applications at 160 gallons per acre.

Two sprayers for the application of sprays to grapes were compared, using a DDT spray. A "fixed spar" sprayer deposited a DDT residue of 3.4 parts per million, while an "overhung boom" sprayer deposited a DDT residue of 3.6 p.p.m. under identical conditions in the same orchard. The difference in residue deposit could not be considered significant.

An air-blast sprayer was used to apply methoxychlor to grapes, using three different air speeds indicated by fan speeds of 1,914, 2,807 and 3,700 r.p.m. Identical average residue deposits were obtained at fan speeds of 1,914 and 2,807 r.p.m. Increasing the fan speed to 3,700 r.p.m. increased the average residue deposit from 2.4 to 2.8 p.p.m. of methoxychlor.

Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

Project activities with aircraft in Oregon during 1962 were primarily confined to installing a 250 horsepower engine in the Rawdon T-1 airplane; completing assembly of the aircraft, designing, fabricating and testing a streamlined dry materials distributor; and working on overhaul of a Bell 47D-1 helicopter which was received on surplus. Fixed wing aircraft were used to conduct spray pattern tests, granular pattern studies, spray penetration test on pole beans, and a series of experimental applications of a granular insecticide to field plots of red clover.

Spray deposit pattern tests were conducted in Oregon with two low-wing monoplanes, namely, a Rawdon T-1 and a Piper PA-25 "Pawnee". Both aircraft were powered with 150 horsepower engines. These tests showed that a symmetrical nozzle arrangement produced as uniform a deposit pattern across the treated swath as a non-symmetrical arrangement. Pattern tests conducted in 1962 after the Rawdon aircraft was equipped with a 250 horsepower engine and larger propeller, showed that the larger engine and propeller did not materially change the overall distribution of the deposited spray over that obtained with the smaller power unit.

Early in 1962, a distributor for granular materials which was developed on the project in Oregon, was mounted beneath the Rawdon airplane. This distributor was provided with endless belts to convey the dry materials to points of release. Performance tests, including deposit pattern studies, were conducted to determine points of release when all outlets were contributing. These performance tests showed that it was necessary to keep the outlets covered except during the application run. An effective 38-foot swath was obtained, however, at higher discharge rates, the outlets tended to clog when the depth of a granular material was near the design maximum and fingers or rakes were used to remove the material from the belt.

The distributor was modified to release the material from the top instead of from the bottom of the unit. This was accomplished by installing dual purpose gates in the top of the distributor, i.e., when gates are closed they prevent the material carried on the belt from sucking out and when open, act as adjustable scoops which remove a predetermined quantity at each location and release it over the top of the distributor. Evaluation tests of this method and position of release will be conducted in 1963.

Applications of a granular insecticide were made to five fields of red clover. These experimental applications were made to develop a safe and effective method of control for the lesser clover leaf weevil, the clover root curculio and the clover root borer. Control evaluations will be made in 1963.

Two airplanes owned and operated by commercial applicators were tested in cooperation with the Ohio Station for applying fungicide sprays to sugar beets to control *Cercospora* leaf spot. One plane was a Piper "Pawnee" with conventional boom and nozzle equipment. The other was a Piper "PA 18" fitted with two "Micronair" spraying units. Spray was applied at two rates, five and ten gallons per acre with both airplanes. Deposit pattern determinations were made with both aircraft using the copper fungicide spray formulation applied. The boom and nozzle unit gave the most uniform application but the "Micronair" equipment gave more uniform atomization. The performance of the two planes was very similar in terms of disease control at both gallonage applications used. The 10 gallon per acre rate was more effective than five gallons per acre rate with both units. However, the disease control was relatively ineffective compared to the hydraulic and air-blast ground equipment. Maneb fungicide spray gave better control than the copper sprays in this test.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Basic Studies in Aerosols and Spray Formation

Braze, Ross D. June, 1962. Polarography and its Application to Pesticide Deposit Analysis. American Society of Agricultural Engineers Paper No. 62-121.

Soil Fumigation

Wilson, J. D. and Hedden, O. K. 1962. Root Knot Infestation and Winter Injury to Nursery Stock and its Reduction by Soil Treatment. Down to Earth, Summer, 1962. Vol. 18, No. 1, pp. 11-13.

Insect and Disease Control by Ground Equipment in Vegetables and Other Low-Growing Crops

Deonier, Calvin E., Getzendaner, C. W., Young, V. D., and Winterfeld, R. G., February, 1963. Mylar Plastic Tags for Sampling Spray Deposition on Individual Leaves and Surfaces. Journal of Economic Entomology, Vol. 56, No. 1, pp. 114-115.

Young, V. D. November, 1962. Equipment Calibration for Field, Row Crop, Band and Aerial Applications. Oregon Insect Control Handbook, 1962.

Wilson, J. D., Irons, Frank, and Henry, James. 1963. Experiments in the Control of *Cercospora* Leaf Spot of Sugar Beets - 1962. Botany and Plant Pathology, Series 42, Ohio Agricultural Experiment Station.

Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-Growing Crops

Winterfeld, R. G., Young, V. D., Deonier, C. E., and Getzendaner, C. W. 1963. Piper PA-25 "Pawnee" Spray and Granular Distribution Patterns. Agricultural Research Service, ARS 42-84.

ELECTROMAGNETIC AND ULTRASONIC ENERGY FOR INSECT CONTROL AND OTHER FARM USES

Agricultural Engineering Research Division, ARS

Problem. Electromagnetic radiation has many established farm uses but research indicates many other highly useful potential capabilities in farm production, such as killing insects harmful to stored grain without leaving residues. To minimize the use of possibly hazardous chemicals and their residues in food products as much as possible, there is need for widespread investigation of non-chemical pest control methods, such as study of insect response to all possible types of radiation and sound and exploitation of weak physical links in the life of particular insects. There is need for detecting or removing insects in food processing plants, including fruit flies in tomato canning plants, and larvae of the cabbage looper and imported cabbage worm that may be clinging to spinach leaves when delivered to the processing plant. Treatments also increase the percentage of germination for some seeds and would therefore enable the establishment of good stands with lower investments for seed.

USDA PROGRAM

The Department has a continuing long-term program of basic and applied research involving agricultural and electrical engineers and physicists working cooperatively with USDA entomologists and with the Experiment Stations of eight States. Electrical and physical methods of vegetable insect control and light trap design are studied in Indiana, with financial assistance from the Indiana Electric Association through the Purdue University Experiment Station. Research on electromagnetic energy for conditioning seed to improve germination and emergence is carried on in Nebraska, Tennessee and Washington. The Federal scientific effort in this area is 1.1 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Electric Traps for Vegetable Insects

Research on the use of light traps for controlling insects in home vegetable gardens was continued for the fifth consecutive season in cooperation with the Departments of Agricultural Engineering and Entomology of the Purdue University Agricultural Experiment Station, Lafayette, Indiana. This work was partially supported by a grant from the Indiana Electric Association.

Plots, 60' x 60', isolated 200 feet apart, in which sweet corn, cucumbers, and tomatoes were planted, were subjected to four different lighting conditions as follows: (1) unlighted, (2) five blacklight (BL) lamps in a fan-type trap, (3) five BL lamps in an electric-grid type trap, and (4) five green-photo lamps in a fan-type trap. Also, three different insecticidal applications were provided for cucumbers in the plots, namely: (1) no insecticide, (2) application of dieldrin to time of flowering, and (3) application of dieldrin throughout the season.

The yield from cucumber plants protected from striped and spotted cucumber beetles by a combination of BL lamps throughout the season and insecticide, either throughout the season or until time of flowering, was significantly higher than when the plants were protected by insecticide alone or lamps alone. Similarly, in 1961, cucumber plants protected by dieldrin to time of vining plus a light trap, equipped with either five 15-watt BL lamps or a combination of two 15-watt BL and three 15-watt green-photo lamps throughout the season, yielded as much as unlighted plants sprayed throughout the season and higher than unlighted plants sprayed to time of vining. These findings indicate that it may be possible to reduce the cost of protecting cucumbers from cucumber beetles by using light traps and reducing the number of insecticide applications.

Results from 5 years (1958-62) of similar experiments show that the yield of cucumbers was increased significantly over that of untreated checks when they were protected from striped and spotted cucumber beetles by one light trap equipped with either three or five 15-watt fluorescent BL lamps. Five BL lamps per trap gave better protection than did three, and BL lamps gave consistently better protection than did green fluorescent lamps and combinations of BL and green lamps.

The 1962 results on the protection of tomato plants from tobacco and tomato hornworms indicated that one light trap, equipped with five 15-watt BL lamps per plot, reduced the percentage of plants infested from 75 percent in the unlighted check to 12 percent, and the average percent of foliage eaten per plant from 6 percent in the check to less than 0.04 percent. No infestation of corn earworms occurred on these tomatoes.

Tests on the protection of sweet corn in 1962 indicated that European corn borer infestation was so slight that no significant damage occurred under any treatment. However, in the late planting of corn, the general population of corn earworms was high and all plots were completely infested.

In cooperation with the Virginia Agricultural Experiment Station and the Virginia Truck Experiment Station, electric insect traps were operated at two tomato canneries in eastern Virginia to determine the relative attractiveness to fruit flies of two different types of lamps. Fruit flies are of significant importance in the tomato canning industry. In 13 nights the trap with a blacklight lamp attractant caught 178,000 fruit flies, which was about seven times greater than the number caught in the trap with an incandescent lamp. Limited investigation will be continued to determine if traps are effective in reducing the number of eggs deposited by flies on tomatoes.

Light traps have been operated the past 10 years near Ames, Iowa, in cooperation with the ARS European Corn Borer Investigations Laboratory and the Iowa Agricultural and Home Economics Experiment Station. Corn borer infestations were relatively low in Iowa in 1962. A total of 8,097 borers

was captured in four traps. As in the past, a trap with a single 15-watt BL fluorescent lamp captured more corn borers than any other trap. Traps with 200-watt incandescent lamps captured a higher ratio of male to female borers than did those with 15-watt BL fluorescent lamps. The Extension Service operated four ARS-furnished survey traps in various parts of Iowa in 1962. Reports on the infestation of 15 economic insects based on the light trap catches were furnished to county extension directors and other cooperators. Insect traps will be operated near Ames in 1963 with the same cooperators as in the past.

Corn earworm moths released in a free-flight response laboratory in cooperative work at Purdue University responded to blacklight lamps at lower temperatures than did striped cucumber beetles. Earworm moths caught live in the field using blacklight insect traps were released in the free-flight chamber and were attracted to an energized electrocutor grid using no additional attractant.

Electromagnetic Radiation Equipment for Seed Treatment

Radiofrequency Energy for Vegetable Seed Treatment. Effects of radio-frequency (RF) treatment on germination of several different vegetable seed lots were tested in cooperation with the Asgrow Seed Co. Treatment was found to accelerate the germination of several lots of spinach seed. Emergence from soil in greenhouse tests was also very noticeably speeded up. Two lots of tomato seed tested also showed increased rates of germination. The germination for an okra seed lot was substantially increased by treatment which reduced the percentage of hard-seeds. Work will continue on evaluation of RF treatment for improving vegetable seed germination.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

- Hollingsworth, J. P., Hartsock, J. G., and Stanley, J. M. January 1963.
Electric Insect Traps for Survey Purposes. ARS 42-3-1, U. S. Department of Agriculture.
- Nelson, S. O. 1962. Radiation processing in agriculture. Transactions of the ASAE, Vol. 5, No. 1, pp. 20-25, 30.

II NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

UTILIZATION RESEARCH AND DEVELOPMENT

Western Utilization Research and Development Div., ARS

Problem. Vegetable crops, in general, are perishable and seasonal and thus, are subject to supply and price fluctuations to the disadvantage of the agricultural economy. In order to expand markets and stabilize prices, new and improved processed products are needed that will be more desirable to the domestic and foreign consumer from the standpoint of quality, convenience, stability, nutritive value, safety, and cost. The quality of processed vegetables and the economy of their processing have not improved rapidly enough to increase or even maintain the relative position of vegetables in the American diet, or to increase substantially their contribution to the export trade. The consumption of dry beans and certain other vegetables is limited by the fact that they cause flatulence.

New easy-to-prepare vegetable products are needed, particularly from such commodities as dry beans and peas, which now require hours to prepare. The severe heating required to sterilize low-acid foods, which include most vegetables, seriously impairs the quality of canned products. The stability of all kinds of processed vegetables needs to be improved so that quality and nutritive value will be better preserved during storage and distribution. The safety and effectiveness of new chemical additives, needed to improve the quality and stability of processed vegetables, must be established. Better methods of removing residues of agricultural chemicals from vegetables for processing are urgently needed, as are procedures for decontaminating vegetables exposed to radioactive fallout. Of vital importance is research to reduce the costs of processing in order that the farmer may receive a larger share of the consumer's dollar.

Applied research on these practical problems must be supported by a strong program of basic research on the chemical constituents of vegetables responsible for flavor, color, and texture; on the reactions these compounds undergo before, during, and after processing; on constituents having biological activity; on the microscopic structure of vegetables and vegetable products; and on the micro-organisms which cause spoilage or loss of quality in these products.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic research on vegetables and the application of science to new and improved products and processes is conducted at the Division headquarters at Albany, California, in field stations at Pasadena, California and Puyallup, Washington; by contract at Urbana, Illinois, and Davis, California; and by grant funds under P.L. 480 in Cambridge and Chipping-Campden, England. Fundamental studies are conducted on the chemistry of

vegetable flavor and vegetable pigments, the mechanism of heat resistance in bacterial spores, the composition of dry beans as related to cooking quality and flatulence-producing characteristics, the factors affecting deterioration of dehydrated vegetables, and the microbiology of raw vegetables for processing. Applied research is conducted to develop new and improved products to increase the utilization of vegetables including new, high quality concentrated and dehydrated products and products of improved convenience of use, processes for producing these, and selection of improved processing varieties.

The Federal program of research in this area includes a total of 43.5 professional man-years including two scientists whose salaries are provided by the California Lima Bean Advisory Board operating under a State Marketing Order; two, by the United States Brewers Association; one, by the National Association of Frozen Food Packers, and one on half-time, supported by the National Canners Association. Of the total, 26.8 are assigned to chemical composition and physical properties and 16.7 to new and improved food products and processing technology. In addition the Division sponsors three grants under P.L. 480 on basic research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Vegetable Flavor Components. Flavor investigations of vegetables have been advanced by continued use of highly sensitive new equipment for the separation and identification of volatile components. Sulfur-containing compounds known to be powerful odor producers are being identified in green peas and hop oil. Basic studies on the sulfur compounds related to flavor of onions, cabbage, and related vegetables are approaching conclusion. A new basic study of flavor constituents of tomatoes has been initiated. Research emphasis has been placed on the sulfur-containing constituents and other volatile compounds of vegetables in order to develop objective methods for estimating flavor of vegetables to control flavor loss or deterioration resulting from chemical or enzymic action, and restore the flavor in dehydrated products. Volatile sulfur-containing components from onions have been extracted, separated, and identified. A new colorimetric reagent, N-ethylmaleimide, was discovered which will distinguish thiolsulfinates from the closely related thiolsulfonates, when both are involved in the flavor of onions. The amino acids that are precursors to the volatile sulfur-containing compounds were identified in onions. An enzyme preparation from onions that is capable of transforming the flavor precursors present to volatile flavors, was isolated and characterized. This enzymic reaction was identified, and pyruvic acid determined to be an important reaction product. It was demonstrated that the flavor of dehydrated onions can be enhanced by drying under conditions that will preserve this enzyme system. The production of pyruvate from this enzymic reaction formed the basis of a test for onion pungency. The quantity of pyruvate produced in the enzymic reaction is a measure of the pungency of either fresh or dehydrated onions.

Values obtained by the simple and rapid procedure were found to correlate well with taste panel determinations of the olfactory threshold of onions. The test is useful and has been adopted by the domestic dehydration industry for selecting raw materials for processing and by plant breeders to obtain varieties of onions more suitable for processing.

The chemistry of volatile components connected with food flavor has advanced spectacularly in recent years by applying gas-liquid chromatography techniques. High instrument sensitivity is achieved using dual columns with dual flame ionization detectors and programmed temperature control. A new combination for separation and detection of volatiles was instituted using gas-liquid chromatography in connection with the time-of-flight mass spectrometer. This combination provides separation and identification of incredibly minute amounts of substances, including materials whose separate existences are transitory. Refinements in separation and detection of volatile components do not eliminate need for large-scale extraction so as to recover workable amounts of substances that exist in the parts per million concentration range of the original food product. Identifications of some classes of flavor constituents continue to defy existing gas-liquid chromatography and other ultramicro methods. A solvent extraction facility is under construction and nearing completion at Albany, California that will allow for extraction with necessary low flash point solvents on a sufficiently large scale to make possible identifications not heretofore possible. Extractions will be obtained in these new facilities with much more complete knowledge of raw material than was ever possible when working with commercial samples.

A basic study of the volatile flavor components of hop oil is supported in part by the United States Brewers' Association, which provides the salaries of two chemists. The long-range purpose of this project is to isolate and characterize flavor components and to study their chemistry. Analysis of one sample of hop oil provided mass spectra for 59 compounds, 23 of which were identified by their mass spectral patterns and gas-liquid chromatography retention times, 11 others were tentatively identified, and empirical formulas were obtained for most of the other compounds. Analyses have been obtained on hop oils from five different varieties using temperature programmed, capillary gas-liquid chromatography and by chemical separation methods. Samples of hops that had been evaluated for aroma by the United States Brewers' Association Hop Committee were obtained to compare direct vapor injection gas chromatograms with the aroma results. Preliminary findings indicate a correlation between the Hop Committee's aroma evaluation and the gas-liquid chromatography pattern obtained.

Cooperative work, supported in part by the National Cannery Association, which provides the salary of a chemist assigned half-time to the project, is conducted on the composition of peas, to provide a basis for technological improvement of canned pea flavor. This project has attempted to develop instruments to measure flavor more objectively and gather more complete data on the composition of volatile components from peas. Considerable progress

has been made in past years in identifying components of peas, many of which exist only in minute concentration. To obtain suitable quantities of volatile materials from peas for chemical studies, volatile material was collected above a commercial pea blancher. The collection equipment was operated continuously for 17 days and a total of 200 gallons of condensate was collected. Vapor above the condensate was collected on activated charcoal in a trap. The volatile material from peas was extracted from the charcoal with various solvents. Separations and identifications were made using gas-liquid chromatography and other procedures. Studies were initiated to seek correlations between individual compounds detected by these sensitive methods and organoleptic evaluations.

Subjective evaluations of flavor are being made also on purified organic compounds, such as those from volatiles which we suspect affect product flavor. A trained panel determined individual odor thresholds of aqueous solutions of these substances. This is one phase of a systematic approach to provide necessary correlations between the chemistry of volatile compounds and the flavor of foods. In order to study the effect of mixed systems, several compounds have been assembled in sub-threshold concentrations and evaluated. From preliminary studies it appears that there is an additive relationship between chemical compounds in olfactory response. Thus, the aroma threshold of a ten-component mixture was identified by test panel when each of the components existed at one-tenth of its individual threshold concentration. This finding is an important early step toward interpretation in terms of flavor of the complicated chromatograms obtained in advanced chemical studies.

2. Nature of the Heat Resistance of Bacterial Spores. The extreme resistance of bacterial spores to heat necessitates processing treatments which bring about flavor, color, texture, and nutritional deterioration in canned vegetables. A basic investigation of the nature of heat resistance exhibited by spores is expected to uncover facts that will make milder processes possible. The temperature dependent heat adaptation of B. megaterium spores has been studied in the temperature range of 4 to 65° C. Heat resistance increases of 50-fold were observed. The uptake of cations by spores in neutral calcium salt solutions indicates that heat adaptation consists of calcium loading of the spore cation binding system. This new knowledge of the high cation exchange capacity of dormant spores and structural information obtained by electron microscopy tend to support, although not prove, the hypothesis advanced by Department scientists that spore resistance to heat is connected with a dehydration process of constriction in the dormant spore rather than with a theoretical water-impermeable barrier. Fractionation and identification of spore components and structures have been materially advanced by the dry rupture of lyophilized spores in the presence of a large excess of sodium chloride crystals and by studies of ash residue following ultramicro incineration at room temperature with activated oxygen. These new techniques should be helpful in arriving at an ultimate understanding of the heat resistance of bacterial spores.

3. Composition of Dry Beans. The composition of dry beans is being investigated to determine the factor or factors involved in their intestinal effects. A simple, portable apparatus was developed for measuring the amount and composition of human flatus from subjects who have eaten experimental meals of cooked beans. The apparatus is worn by human subjects without undue interference with their normal activities. Flatus is collected and passed through three small glass tubes, one of which contains chemicals that capture the passed carbon dioxide which is one of the major gaseous components of human flatus. Periodic samples of gas are measured by gas-liquid chromatography to determine hydrogen, methane, oxygen, and nitrogen as well as the carbon dioxide. The total carbon dioxide collected and the composition of gas taken at intervals allows for calculations of the total flatus and its composition over a many-hour period following ingestion of cooked beans. Using this human assay technique, a bean fraction has been isolated which contains the major portion of flatulence activities of the whole bean, but represents less than 8% of the original whole cooked bean. Preliminary investigations indicate that this chemical fraction is made up of compounds of molecular weight less than 10,000. This fraction contains a great number of chemical compounds, including peptides, pigments, tannins, free amino acids, monosaccharides, and protein complexes involving lipids and carbohydrates. It probably does not contain higher molecular weight materials such as proteins, pectins, gums and dextrans, cellulose and starch.

By informal cooperation with the Clinical Investigation Center of the United States Naval Hospital in Oakland, California, medical supervision is given to these studies. In addition, because the flatulence principle in beans is thought to increase peristalsis in the human digestive tract, the Naval Hospital has undertaken a cooperative study of peristalsis. Two procedures are being used to study peristalsis. In one, a small radio transmitter that responds to minor pressure differences is swallowed and peristaltic action, as reflected by pressure differences in the intestines, can be recorded. The differences in the pressure patterns following normal diets and diets containing controlled amounts of beans, and the transit time of the transmitter through the intestines, is providing useful information on determining the effect of bean diets on intestinal reaction. In addition, the transit time for gas passage through the intestines is being measured by administering oxygen by stomach tube to a subject after a normal diet and bean diet, and noting any difference in the time required for an increased oxygen-to-nitrogen ratio to appear in the flatus.

From time to time, commercial samples of bean products and recipes and additives suggested to prevent flatus have been obtained and tested by the new assay technique. To date none of these samples or ideas has been found to reduce the flatulence which follows ingestion of dried beans.

Closely coordinated with these studies at Albany, California is supporting research conducted by contract at the University of Illinois. Methods for measuring flatulence in human and animal subjects are being developed, and research is underway on the physiological mechanism underlying flatulence.

A simple portable electronic device for measuring and analyzing egested flatus has been devised and is being tested. If successful, this technique will be particularly useful when experiments are to be conducted with large panels of human subjects. In addition, test tube studies have been conducted in which cooked dry beans have been found to catalyze the release of carbon dioxide gas from solutions containing bicarbonate ions. The pancreas normally secretes large amounts of bicarbonates into the upper intestine.

Animal studies are continuing at Albany, California both feeding beans to rats and by injecting bean components in their upper intestines when anesthetized. As previously reported, irritation of intestine walls and intestinal swelling have been observed. Research procedures have been refined so that sections of the intestine can be excised and weighed. It has been found that weights of treated strips of intestines are 50 to 70% heavier than comparable controls when an injection of ethanol extract of beans has been made into an intestinal loop. Earlier tests were made with pentobarbital anesthesia which restricts peristalsis. Urethane now allows peristalsis to continue in these studies. The injection of the alcoholic fraction results in increased peristalsis and distension of the intestine with gas as well as with mucus. The largest volume of gas was produced when bean extracts were inserted into the rat's stomach by stomach tube. Starved rats are used for this experiment and peptone was added to stimulate the flow of gastric juices. The effect of the bean extract was striking.

4. Composition of Beans and Peas as Related to Cookability. Compositional studies, supported in part by the California Lima Bean Advisory Board, which provides the salary of two scientists, are directed towards understanding the effect on cooking of qualitative and quantitative changes in the proteins of large Lima beans. Changes in cooking characteristics of Lima beans were found to parallel closely changes among the proteins, which comprise about 25% of dry bean solids. Basic information will be required in continuing work to determine the specific chemical and physical changes among proteins during maturation, processing, and storage which may change the cookability of beans. In storage studies with large Lima beans, pintos, and Sanilacs (a Michigan pea bean variety), moisture content of beans has a dramatic effect on the maintenance of their cooking qualities during storage. Minimum changes in cookability occurred in low-moisture beans (between 8 and 10%) while moderately high-moisture beans (12 to 14% required 5 to 10 times longer cooking after a year's storage at 90° F. and several-fold more cooking time after storage at 70° F.

A basic investigation of compositional factors that might be related to the cookability of dry peas is being conducted at the Fruit and Vegetable Canning and Quick-Freezing Research Association Laboratories at Chipping-Campden, England, supported by a grant under P.L. 480. It was reported earlier that the texture of cooked dry peas is determined by the viscosity of the intercellular pectic material and the extent to which tissue cells swell during cooking.

The extensibility of cell wall was shown to dominate texture. Phytic acid concentration, which was earlier thought responsible for texture, was shown to be of little or no significance. In test tube studies, insoluble salts of phytic acid were formed in the presence of potassium, calcium, and magnesium ions, the composition of the insoluble salts depending upon the ratio of the cations present. When peas were cooked in water containing calcium ions, only part of the absorbed calcium was complexed as an insoluble salt of phytic acid. As the external calcium concentration was raised an increasing amount of calcium was absorbed at other sites in the tissues, which it toughened. As the insoluble phytic acid salt increased, a greater proportion of the magnesium which is naturally present in the peas was complexed in the salt, leading to a replacement of magnesium by calcium in other parts of the tissue. Histological studies showed that in the uncooked pea, calcium was predominantly in the inner cell wall. Cooking drives this calcium into the cell contents. As the cell wall loses calcium its plasticity is increased, allowing greater cell expansion and a corresponding softening of the tissue. When peas are cooked in hard water, or in the presence of calcium salts, the removal of calcium from the cell wall is counteracted by the absorption of calcium from solution and the peas remain tough.

5. Vegetable Pigments. The retention of natural color in processed vegetables affects the acceptability of products. Basic research is conducted at the Department's Laboratory in Albany, California on chlorophyll and at the Low Temperature Research Station in Cambridge, England under a P.L. 480 grant on carotene and its volatile oxidation products. Research in England has shown that color of processed vegetables is related to other quality factors. Beta-carotene, a precursor of vitamin A, is the principal yellow color in carrots. As this color disappears, there is a concurrent development of undesirable odors and flavors which are breakdown products of the carotenes. Investigations of the complicated chemical mechanisms involved in the breakdown of beta-carotene are being conducted in the expectation that means will be found to stabilize vitamin A, and improve the color and nutritional quality of processed yellow vegetables, and avoid undesirable flavors that may result from processing and subsequent storage of processed products. Chlorophyll derivatives and degradation products are being measured by various laboratory procedures. Column chromatography, radial and centrifugal paper chromatography, and thin-layer chromatography are being employed. Highly purified chlorophyll a, chlorophyll b, pheophytin a, and pheophytin b, have been obtained as reference standards for analytical work. Separation of pheophytin a from pheophorbide a needs further refinement. The extreme instability of chlorophyll immensely complicates the research in this area.

6. The Role of Sulfur Dioxide in Dehydrated Vegetables. A basic investigation to determine the chemical mechanism of the action of sulfur dioxide to control browning in dehydrated vegetables is being conducted at the Covent Garden Laboratory in London, England, supported by a grant under P.L. 480. As this program approaches completion, evidence of excellent progress is noted in the publication of eight scientific papers with more anticipated.

Without adequate protection, many dehydrated fruits and vegetables will gradually become brown, develop objectionable flavors and odors, and lose in nutritive value. While sulfur dioxide has stopped browning, until recently very little has been known about the mechanism of this treatment. Chemical browning reaction occurs between sugars and amino acids. This chemical reaction is being greatly clarified. When sugar solutions are heated, configurational changes occur, developing unsaturation in the sugar molecule. The rate of browning of such solutions depends on the ease of dehydration of the sugar-derived compounds and upon the reactivity of intermediates produced. These factors depend in turn upon the molecular configuration of the sugar present initially and on the environment. Where sulfite is added to prevent discoloration of sugar and amino compounds, it has to deal not only with the initial sugars but also with the new compounds formed. Sulfite reaction with the initial sugar hinders the formation of some new compounds whose reactivity in terms of discoloration is greater than the initial molecular configuration of the sugar present. This new knowledge provides a basis for developing new methods for protecting dehydrated fruits and vegetables from non-enzymic browning, where sulfur dioxide is not satisfactory or its use must be limited.

7. Histological Studies of Vegetable Tissues. Basic studies on the texture of frozen vegetables were initiated with support from the National Association of Frozen Food Packers, which supplies the salary of one scientist. Shear press texture evaluations were made of green beans following blanching, freezing and thawing, and cooking operations. A substantial shear press reading decrease following freezing and thawing indicates this as a major area in which to concentrate investigations of textural change. Two types of damage were observed microscopically in frozen tissue: the thin-walled parenchyma cells were broken, and thick-walled cells were separated. When freezing was very rapid, as by immersion in liquid nitrogen, these two types of damage were not observed. To determine whether the freezing or the thawing operations were principally concerned with the textural changes, two techniques were used to observe the effect of freezing without thawing. In one, frozen green beans were dried under vacuum so as not to thaw and to maintain general tissue configurations and, secondly, the ice was removed from frozen tissues at very low temperature by alcohol. If the freezing is done slowly, damage seems to occur during the freezing so that there is no substantial additional change during thawing. If the product is frozen more rapidly there is little damage during freezing but damage resembling that of the freezing can occur during a subsequent slow thawing operation. Neither blanching nor cooking caused the changes of the freezing and thawing operations. Studies will continue to acquire a better understanding of the physical and chemical changes during freezing and thawing that affect the texture of frozen vegetables. Research will continue with green beans, be extended to carrots, and ultimately to other popular frozen vegetables.

8. Microbial Flora in Fruits and Vegetables. Fundamental studies on the microbial flora within tissues of fruits and vegetables have been concluded in Israel, where they were supported by a Public Law 480 research grant to

the Agricultural Research Station of the Ministry of Agriculture at Rehovot. This study demonstrated certain non-pathogenic bacteria in healthy fruit and vegetable tissue. Only certain bacteria are within the tissue. Many organisms found on the surface are not found inside unless the fruit has been damaged; the flora found in fresh fruit remain harmless and have only limited growth in the intact plant. The organisms do multiply during certain processing operations such as brining where bacterial growth is necessary to the fermentation involved in preservation. In this case conditions must be arranged so that the fermenting bacteria will overcome the harmful bacteria present within the fruit and vegetables, or undesirable bacterial growth may bloat or putrefy the brined product.

B. New and Improved Food Products and Processing Technology

1. Foam-mat Drying. Laboratory and pilot plant investigations continue on the application of the foam-mat drying process invented by Department engineers at Albany, California. Informal cooperation continues with industry representatives who are interested in the commercial application of foam-mat drying. Three commercial-scale foam-mat drying units now exist. Two have already been used for commercial-scale research, and the third has produced commercial lots of foam-mat dried tomato paste, pure lemon juice, and lime concentrate. A procedure was developed to further reduce the moisture content of already foam-mat dried powders to eliminate the necessity for in-package desiccants for extremely hygroscopic materials. Rotating vacuum drying equipment, using lime as a moisture acceptor and an electrically heated outer cylinder was designed. Orange powder, an extremely hygroscopic material, was reduced from 3-1/2 to 1% moisture by tumbling 2-1/2 to 3 hours at 130° F.

A method was developed to reduce the bulk and improve the apparent color of foam-mat dried powders. The powders were run between hot rolls to increase their density and provide for more efficient packaging. Conditions for rolling various products were established based on the sensitivity of the products to temperature and the requirements of density specifications. For example, foam-mat dried orange powder was rolled at temperatures between 130 and 180° F. while tomato powder was rolled at temperatures as high as 205° F. The bulk density of foam-mat dried tomato powder has been approximately doubled by this process to give a value of about 0.7 grams per milliliter. The rate of reconstitution in cold water is not significantly changed.

Foam-mat dried tomato powder from concentrated tomato juice was more stable than a commercial preparation of tomato paste. In order to achieve maximum yield of tomato solids in paste manufacture, more severe heat treatment and finishing operations are involved than tomato juice. Seed, peel, stem, and fiber fragments find their way into tomato paste. These constituents may be responsible for poor stability of tomato powder made from commercial paste. Investigations are continuing to determine what components and processes may be involved in this reduction of tomato powder stability.

2. Dry Bean Products. The slow cooking of dry beans and peas deters their utilization. The preparation of dry bean, pea, and lentil powders by drum drying slurries of cooked legumes with and without seasoning was previously reported. Samples of these products have been widely demonstrated with the assistance of the manager of the California Lima Bean Advisory Board. Basic research and research on other bean products is partly supported by the California Lima Bean Advisory Board. Packaging requirements and storage stability of bean powders were studied. Satisfactory flavor was obtained with nitrogen-packed products at 5% moisture stored at 100° F. for six months. Air-packed samples and powders at 10% moisture content were much less stable. An antioxidant in the air-packed sample improved stability but not as much as nitrogen packing. Investigations continued to develop processes which would reduce the cooking time for dry Lima beans. Beans were treated with solutions of food grade substances capable of: (a) complexing metallic ions; (b) dissociating protein complexes and solubilizing proteins; and (c) retarding oxidative processes. Beans treated with these chemicals and dried were completely hydrolyzed and tenderized in boiling water within 30 minutes. The cooked beans had acceptable appearance, texture, and flavor. Shear press evaluations of the freshly prepared beans indicated that the texture of the treated beans was comparable with beans soaked overnight in the usual way and cooked 40 minutes or longer.

3. Processing Quality of Vegetable Varieties. The evaluation of processing quality of vegetable varieties is a continuing program in cooperation with the Washington State Experiment Station at Puyallup, Washington. Increasing attention is being given in western Washington to the introduction of new processing vegetables. With improved varieties of Brussels sprouts available and new developments in mechanical harvesting, larger packs of Brussels sprouts and lower cost to the consumer will be possible. Almost all of the domestic pack of frozen Brussels sprouts is grown in a small coastal area south of San Francisco in California. It appears likely that other growing areas, and western Washington in particular, have conditions for commercial production of Brussels sprouts if improvements in variety and harvest methods can be developed. Interest in western Washington is also focused on the Romano bean and the Fava bean. Varieties of these two vegetables have been grown experimentally at the Western Washington Experiment Station and frozen by Department scientists for evaluation. In addition, 23 varieties of peas and 20 varieties and selections of snap beans were frozen and evaluated in cooperative studies with horticulturists.

4. Frozen and Dehydrofrozen Vegetables. Analyses and evaluations of stored frozen and dehydrofrozen peas indicate little or no difference in color stability between the two products under rather severe storage conditions (i.e., 45 days at 20° F.). There has long been a question as to whether the concentration of reactants resulting from the dehydrofreezing process would harm stability. However, this does not seem to be the case and the dehydrofrozen peas have as good color stability as frozen peas. The color of frozen Brussels sprouts has always been a commercial problem. Brussels sprouts

are so large and so variable in size that uniform blanching is difficult. Overblanching results in loss of their bright green, garden-fresh color. Blanching studies were conducted over a broad range of conditions. Analyses of chlorophyll conversion are completed and results of these studies are currently being evaluated and will be published as a guide to commercial freezers of this vegetable.

5. Fouling of Heat Transfer Surfaces. In the concentration of fruit juices and tomato products, fouling of heat transfer surfaces causes serious economic losses. In earlier work, a resistance-impedance thermometer system was developed to obtain accurate surface temperatures and related heat transfer measurements that were used to discover that fouling was markedly more rapid when products were being warmed compared to when they were being boiled, and to indicate that fouling was increased by increasing surface temperature, vapor fraction in evaporator tubes, and product viscosity. A relationship between protein denaturation and fouling has led to the initiation of studies of the effect of proteolytic enzymes on evaporator surface fouling. Measurements are being extended to rotating steam coil evaporators as they gain commercial acceptance. Simpler generalizations are being sought so that information from these studies can be applied to existing evaporator installations as well as to the design of new evaporators.

6. Microbiology of Frozen Vegetables. In recent years an increasing awareness of microbial sanitation has come to the vegetable freezing industry. Large institutional buyers of frozen vegetables that will be used for remanufacture have specified maximum viable count of bacteria as a quality requirement. Department scientists, through informal cooperation with the vegetable freezing industry in the Pacific Northwest, have conducted plant surveys to assist in improving sanitation procedures. Microbial surveys were carried out during the last year on 5 pea, 1 bean, and 5 corn lines. A typical source of serious contamination was frequently found in improperly sanitized conveyor belts. In one case a 50- to 60-fold increase in bacterial count in peas was observed following passage over two short inspection belts. Contamination from these belts was reduced to a negligible level by continuous spraying with chlorinated water. Use of chlorinated water in fluming in vegetable processing plants has materially reduced bacterial contamination. Such informal cooperation will continue by arrangement out of the Puyallup field station in the State of Washington.

PUBLICATIONS AND PATENTS REPORTING RESULTS
OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

- Alderton, Gordon and Snell, Neva. 1963. Base exchange and heat resistance in bacterial spores. *Biochem. and Biophys. Res. Communications* 10(2), pp. 139-143.
- Burton, H. S., McWeeny, D. J., and Biltcliffe, D. O. 1962. Development of chromophores in carbonyl-amino system. *Nature* 196(4849), pp. 40-42. 1/
- Burton, H. S., McWeeny, D. J., Pandhi, P. N., and Biltcliffe, D. O. 1962. Fluorescent compounds and non-enzymatic browning. *Nature* 196(4858), pp. 948-950. 1/
- Burton, H. S., McWeeny, D. J., and Biltcliffe, D. O. 1962. The influence of pH on SO₂-aldose-amino-reactions. *Chem. and Indus.* 38, pp. 1682-1683. 1/
- Burton, H. S. and McWeeny, D. J. 1963. Nonenzymatic browning reactions: consideration of sugar stability. *Nature* 197(4864), pp. 266-268. 1/
- Burton, H. S. and McWeeny, D. J. 1963. Role of phosphatides in nonenzymatic browning. *Nature* 197(4872), pp. 1086-1087. 1/
- Carson, J. F. 1963. The separation and characteristics of flavor components from the onion. *Coffee and Tea Industries* 86(6), pp. 30, 31, 45.
- Curl, A. Laurence. 1962. Red pepper carotenoids: the carotenoids of red bell peppers. *J. Agr. and Food Chem.* 10(6), pp. 504-509.
- Ettala, Terttu and Virtanen, A. I. 1962. On the labelling of sulfur-containing amino acids and gamma-glutamylpeptides after injection of labelled sulphate into onion (Allium Cepa). *Acta Chem. Scand.* 16(8), pp. 2061-2063. 1/
- Gmelin, Rolf and Virtanen, A. I. 1962. Neoglucobrassicin, a second SCN⁻ precursor of the indole type in Brassica species. *Acta Chem. Scand.* 16(6), pp. 1378-1384. 1/
- Gmelin, Rolf and Virtanen, Artturi I. 1962. Neoglucobrassicin, another thioglucoside in Brassica species with an indole group in the molecule. *Suomen Kemistilehti B* 35, p. 34. 1/
- Heckly, R. J., Dimick, R. L., and Windle, J. J. 1963. Free radical formation and survival of lyophylized microorganisms. *J. Bacteriology* 85(5), pp. 961-966.

1/ Research supported by P.L. 480 funds.

- Jahnsen, Vilhelm J. 1962. Complexity of hop oil. *Nature* 196(4853), pp. 474, 475.
- Korytnyk, W. and Metzler, E. 1962. Formation of raffinose and stachyose in Lima beans (Phaseolus Lunatus). *Nature* 195(4841), pp. 616, 617.
- Matikkala, E. J. and Virtanen, A. I. 1962. A new gamma-glutamylpeptide, gamma-L-glutamyl-S-(prop-1-enyl)-L-cysteine in the seeds of chives (Allium Schoenoprasum). *Acta Chem. Scand.* 16(10), pp. 2461-2462. 1/
- McWeeny, D. J. and Burton, H. S. 1962. A simple radio-chromatogram scanner. *J. Sci. Instr.* 39, p. 398. 1/
- McWeeny, D. J. and Burton, H. S. 1962. Sulphites and carbonyl-amino chromophore development. *Nature* 196(4849), pp. 40-42. 1/
- Michener, H. D. and Lewis, J. C. Sept. 18, 1962. Preservation process with quaternary ammonium compounds. U.S. Patent No. 3,054,678.
- Moisio, T., Spärr, C.-G., and Virtanen, Artturi I. 1962. Mass-spectral studies of the chemical nature of the lachrymatory factor formed enzymically from S-(1-propenyl)-cysteine sulfoxide isolated from onion (Allium Cepa). *Suomen Kemistilehti B* 35, p. 29. 1/
- Piironen, Eino and Virtanen, Artturi I. 1962. The synthesis of ascorbigen from ascorbic acid and 3-hydroxymethylindole. *Acta Chem. Scand.* 16, pp. 1286, 1287.
- Sacks, L. E. Oct. 23, 1962. Preparation of liquids of graded density. U.S. Patent No. 3,060,130.
- Sacks, L. E. and Bailey, G. F. 1963. Dry rupture of bacterial spores. *J. Bacteriology* 85(3), pp. 720, 721.
- Schwimmer, Sigmund. 1962. Theory of double pH optima of enzymes. *J. Theoret. Biol.* 3(1), pp. 102-110.
- Schwimmer, Sigmund and Mazelis, Mendel. 1963. Characterization of alliinase of Allium Cepa (onion). *Arch. Biochem. and Biophys.* 100(1), pp. 66-73.
- Schwimmer, Sigmund. 1963. Kinetics of L-cysteine sulfoxide lyase of onion. *Fed. Amer. Soc. Expt. Biol. Proc.* 22(2, pt. I), p. 534.
- Teranishi, Roy and Buttery, Ron G. 1962. Aromagram--Direct vapor analyses with gas chromatography. *Reports of Sci. Tech. Commission of Internatl. Fed. Fruit Juice Producers, Berne, Switzerland*, pp. 257-266.

1/ Research supported by P.L. 480 funds

- Teranishi, Roy, Buttery, Ron G., and Lundin, Robert E. 1962. Gas chromatography. Direct vapor analyses of food products with programmed temperature control of dual columns with dual flame ionization detectors. *Analyt. Chem.* 34(8), pp. 1033, 1034.
- Thomas, R. S. 1962. Demonstration of structure-bound mineral constituents in thin-sectioned bacterial spores by ultramicroincineration. *Proc. 5th International Cong. for Electron Microscopy*, Aug. 31, 1962--*Electron Microscopy*, v. 2, p. R-11.
- Virtanen, Artturi I. and Spåre, C.-G. 1962. On the enzymic splitting of S-(1-propenyl)-cysteine sulfoxide and the formation of the lachrymatory factor. *Suomen Kemistilehti B* 35, pp. 28-29. 1/
- Virtanen, Artturi I. and Saarivirta, Maija. 1962. The formation of benzyl thiocyanate in the seeds of Lepidium Sativum. *Suomen Kemistilehti B* 35, pp. 102-104. 1/
- Virtanen, Artturi I. 1962. Some organic sulfur compounds in vegetables and fodder plants and their significance in human nutrition. *Angew. Chem. International Ed.* 1(6), pp. 299-306. 1/
- Virtanen, Artturi I. 1962. Enzymes. IV. On enzymic and chemical reactions in crushed plants. *Arch. Biochem. and Biophys.*, Sup. 1, pp. 200-208. 1/
- Virtanen, Artturi I. and Saarivirta, Maija. 1962. The formation of benzyl nitrile, benzyl isothiocyanate and benzyl thiocyanate in the crushed seeds of Lepidium Sativum. *Suomen Kemistilehti B* 35, pp. 248-249. 1/
- Virtanen, Artturi I. and Matikkala, E. J. 1962. Gamma-L-glutamyl-S-(prop-1-enyl)-L-cysteine in the seeds of chives (Allium Schoenoprasum). *Suomen Kemistilehti B* 35, p. 245. 1/
- Wahlroos, Orn. 1962. Some characteristics of a β -ray argon tetrode detector. *Acta. Chem. Scand.* 16, pp. 1039, 1040. 1/
- Wilson, J. R., Nutting, M-D, and Bailey, G. F. 1962. Use of tetracyanoethylene for removal of visual carotenoid spectra from solutions of pheophytins. *Analyt. Chem.* 34(10), pp. 1331, 1332.
- Wilson, J. R. and Nutting, Marvel-Dare. 1963. Use of ion exchange resin for conversion, separation, and determination of chlorophylls as pheophytins. *Analyt. Chem.* 35(2), pp. 144-146.
- Windle, J. J. and Sacks, L. E. 1963. Electron paramagnetic resonance of manganese (II) and copper (II) in spores. *Biochim. et Biophys. Acta* 66(2), pp. 173-179.

1/ Research supported by P. L. 480 funds.

Wong, F. F. and Carson, J. F. 1963. Paper chromatography of some 2,4-dinitrophenyl S-alkyl-(L)-cysteines and corresponding sulfoxides. *J. Chromatography* 10(2), pp. 242-245.

Wong, F. F. and Carson, J. F. 1963. Drying manifold for spot tests and chromatograms on paper. *Chemist-Analyst* 52(1), p. 20.

New and Improved Food Products and Processing Technology

Bissett, O. W., Tatum, J. H., Wagner, C. J., Jr., Veldhuis, M. K., Graham, R. P., and Morgan, A. I., Jr. 1963. Foam-mat dried orange juice. I. Time-temperature drying studies. *Food Technol.* 17(2), pp. 92-95.

Carlson, R. A. and Morgan, A. I., Jr. 1962. Fouling inside vertical evaporator tubes. *Food Technol.* 16(11), pp. 112-114.

Dietrich, W. C., Nutting, M-D. F., Boggs, M. M., and Weinstein, N. E. 1962. Time-temperature tolerance of frozen foods. XXIV. Quality changes in cauliflower. *Food Technol.* 16(10), pp. 123-128.

Elliott, R. P. and Michener, H. D. 1962. Growth of food poisoning and food spoilage microorganisms at refrigeration temperatures. *Proc. International Inst. of Refrigeration*, Washington, D. C.

Ginnette, L. F., Graham, R. P., and Morgan, A. I., Jr. 1963. Tomato powder by foam-mat drying. *Food Technol.* 17(6), pp. 133-135.

Graham, R. P., Ginnette, L. F., and Morgan, A. I., Jr. June 11, 1963. Preparation of stable dehydrated products. U.S. Patent No. 3,093,488.

Guadagni, D. G. 1963. Time-temperature integrator: A laboratory evaluation. *Frosted Food Field* 36(4), pp. 42-44.

Morgan, A. I., Jr. 1962. Present status of foam-mat drying. Produces good instant powders from liquid foods cheaply. *Food Proc.* 23(12), pp. 56-57.

Morgan, A. I., Jr. and Ginnette, L. F. Nov. 20, 1962. Production of carbohydrates in readily dispersible form. U.S. Patent No. 3,064,722.

Morgan, A. I., Jr. and Kaufman, V. F. 1962. Preliminary investigations of tumbling freeze-drying. *Proc. International Institute of Refrigeration*, Washington, D. C.

Norton, Robert A., Bratz, Walter E., and Wolford, Everett. 1962. Freezer pea variety trials. *Puget Sound Vegetable Grower* 7(4), pp. 2, 3.

- Rockwell, W. C., Lowe, E., Morgan, A. I., Jr., Graham, R. P., and Ginnette, L. F. 1962. How foam-mat dryer is made. Food Engin. 34(8), pp. 86-88.
- Tompkins, Daniel, Crandall, P. C., Norton, R. A., and Wolford, E. R. 1963. Snap bean varietal studies in Western Washington. West. Wash. Hort. Assoc. Proc., annual meeting, pp. 18-21.
- Western Utilization Research and Development Division. 1963. Sixth annual dry bean conference, Los Angeles. Proceedings, 69 pp.

UTILIZATION RESEARCH AND DEVELOPMENT
Eastern Utilization Research and Development Div., ARS

Problem. Vegetable growing occupies over 3 million acres, with a yearly farm value of a billion dollars. Classic studies have revealed their gross composition (moisture, protein, carbohydrate, fat, minerals) but very little is known of the individual constituents that make up these broad classes, and still less about components outside these classes. This ignorance is a limiting factor in the development of new and improved processing methods and processed products. Technological advances have been hampered by insufficient knowledge of the constituents responsible for the color, flavor, and texture of vegetables and the changes these constituents undergo during processing, storage, and distribution. There is need for basic compositional research to provide the fundamental information on which an applied research program can be developed logically and efficiently. Recently-developed equipment and techniques have made it possible to isolate and characterize constituents that could not have been studied effectively with older procedures. There is also need for application of these results to developmental research on new products and new and improved processing technology.

USDA PROGRAM

The Department has a continuing long-term program employing chemists and chemical engineers in basic and applied research on vegetable processing and products. Research (EU) on inhibitors for pectinolytic and cellulolytic enzymes, extractable from plant sources such as grape leaves was completed at Wyndmoor, Pennsylvania, during the past year. Pilot plant research on new dehydrated vegetable products is carried out at Wyndmoor. Research on new processing procedures to produce better quality canned vegetables which was conducted under contract at the New Jersey Agricultural Experiment Station, New Brunswick, has been completed. The Federal (EU) scientific effort assigned to this area totals 2.2 professional man-years and is currently engaged in research on new and improved dehydrated products and processing technology.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Enzyme inhibitors from plant sources. It has long been known that an inhibitor is present in grape leaves that prevents the enzymic softening of cucumbers during brining. It was found that a tannin of the condensed type is responsible for inhibiting this enzymic system. Work at EU under this project was officially terminated on October 12, 1962. Further research on application of the findings to the pickle industry will be conducted by the Southern Utilization Research and Development Division.

B. New and Improved Dehydrated Products

1. Quick-cooking dehydrated vegetable pieces. Methods have been developed for imparting a porous structure to partially-dehydrated vegetable pieces which speeds up their final dehydration and makes them much more readily rehydrated. Following the first stage of drying, the pieces are heated in a "puffing" gun until the water contained within the piece is superheated with respect to steam at atmospheric pressure. The porous structure is the result of the flashing of water vapor from all parts of the piece. Optimum conditions of moisture in the partially dehydrated piece and optimum pressure in the puffing gun vary somewhat from vegetable to vegetable. Thus for developing uniform porosity and ease of rehydration, 3/8-inch carrot dice should be dried to 30-42% moisture content before placing in the puffing vessel and quickly released to atmospheric pressure when 35-40 p.s.i.g. has been reached.

Sweetpotato dice (3/8-inch cubes) were prepared from Maryland Golden (North Carolina production) and Unit #1 Puerto Rico (New Jersey production) varieties by the explosive-puffing process. These products rehydrated in 2-3 minutes' simmering in water, as compared to 40 minutes for conventionally dehydrated dice. The drying time for the explosively-puffed sweetpotato dice was only 5 hours as against 21 hours for pieces of the same size not subjected to puffing. The explosive-puffing process has also been successfully applied to beets and rutabagas, and preliminary experiments have been made with peas and sweet corn.

C. New and Improved Processing Technology

1. Equipment development for explosive-puffing. A cereal puffing gun, such as is used in producing puffed wheat and rice, is the only piece of equipment commercially available for pilot plant investigation of explosive puffing of vegetable tissue. Since the puffing of cereals and explosive puffing of vegetable tissue are fundamentally different, it has been necessary to make changes in the conventional cereal puffing gun.

A larger and improved stainless steel puffing gun (2.5 feet long, 12 inches in diameter) is now in use to provide cost and other data on the production of high-quality vegetable dice.

2. High-temperature short-time canning. This contract research at the New Jersey Agricultural Experiment Station, New Brunswick, on HTST sterilization of canned Eastern vegetables was completed on July 19, 1962, with attainment of the objective. It was demonstrated that HTST sterilization of a number of vegetables results in some improvement relative to conventionally-canned vegetables provided the HTST products are stored under refrigeration.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF
USDA AND COOPERATIVE RESEARCH

Chemical Composition as Related to Processing Characteristics

Fitzpatrick, Thomas J., Talley, Eugene A. and Porter, William L. 1962. Reactions of asparagine in phosphate buffer. Chemistry and Industry, pp. 1983-1984.

Heisler, E. G., Siciliano, James and Treadway, R. H. 1962. Potassium content of juice in relation to blackening tendency of tissue. Food Technology, 16, pp. 120-124.

Zacharius, R. M. and Talley, Eugene A. 1962. Elution behavior of naturally occurring ninhydrin-positive compounds during ion exchange chromatography. Analytical Chemistry, 34, pp. 1551-1556.

Dehydrated Potato Products

Eskew, R. K. and Drazga, F. H. 1962. Potato flakelets--a new dense product from flakes. Food Technology, 16, pp. 99-101.

New and Improved Processing Technology

Drazga, Fred H. and Eskew, Roderick K. 1962. Observations on drum drying mashed potatoes. Food Technology, 16, pp. 103-105.

Ross, L. R. and Treadway, R. H. 1962. A new and rapid method for determining fat in French fried potatoes. American Potato Journal, 39, pp. 207-211. Reprinted as "A rapid method for determining fat in frozen French fried potatoes," Quick Frozen Foods, 25, pp. 107-108.

Treadway, R. H. 1962. The potato starch industry in the U.S.A. Die Stärke, 14, pp. 212-218.

UTILIZATION RESEARCH AND DEVELOPMENT
Southern Utilization Research and Development Div., ARS

Problem. Although extensive progress has been made in recent years in developing stable, attractive, and convenient to use vegetable products, new and improved processed products must be developed and means of stabilizing perishable vegetables provided to minimize the adverse effects of seasonable surpluses and unfavorable markets, and to provide an adequate supply of good food for a growing population. Product quality needs to be improved and processing cost reduced through the adaptation and application of the latest technological developments and nutritional findings. For example, a major problem of the cucumber industry, since most of the crop is brine-cured, is to improve the curing process so that no loss occurs in the value of the cucumber during the brine-curing and storage process and the cost of processing is reduced. As another example, a pre-cooked, dehydrated, sweetpotato product has been developed which has good shelf life, when sealed under an inert gas. It reconstitutes to a product having the characteristics of freshly cooked and pureed sweetpotatoes. Applied research on a pilot-plant scale is needed to obtain additional engineering and processing data applicable to commercial production. Basic research is needed to improve the quality and storageability of the product. There is a continuing need in the use of vegetables for processing to investigate the characteristics of the raw material as these characteristics are affected by climate, soil, cultural practices, breeding and the like. Celery, already an important flavoring ingredient, could become much more important if the factors and constituents responsible for the intensity, variableness, and stability of its flavor could be controlled in processing, and processed products of improved flavor and convenience could be developed. Many vegetables grown in the Southern Region differ in their chemical and physical characteristics from the same crops grown in the more temperate regions; and several vegetable crops are grown almost exclusively in the Southern Region. More utilization research is needed to complement the Federal and State production research programs and to provide cooperation in the form of composition and processing studies.

USDA PROGRAM

The Department has a continuing long-term program involving biochemists, organic chemists, microbiologists, food technologists, and chemical engineers engaged in both basic and applied utilization research studies on vegetables of the Southern Region to develop new or extended uses for these commodities.

Research to develop basic information on chemical composition and physical properties of vegetables, their products and byproducts, is conducted as a basis for efficient research in developing new and improved food products and processing technology. Emphasis at the present time is on investigations of the flavor and aroma components in natural and pure culture

fermented cucumber pickle products, carried out at the U. S. Food Fermentation Laboratory, Raleigh, North Carolina, to provide the basis for producing pickle products of greater consumer acceptability. The North Carolina and Michigan Agricultural Experiment Stations, and the National Pickle Packers Association, cooperate in this research.

In the field of new and improved food products by processing of vegetables, research is being carried out at New Orleans, Louisiana, to improve or modify certain characteristics of the precooked dehydrated sweetpotato flake product with special emphasis on improvement of product acceptance and maintenance of quality during storage. Close cooperation is maintained with the Louisiana Agricultural Experiment Station, which furnishes sweetpotatoes of known history, and industry and industry associations. Research is in progress at the U. S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida, on the development of processed celery products of improved flavor and convenience. Research is also being conducted at the U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas, to develop new and improved processed products from southern grown vegetables other than sweetpotatoes and celery. The Texas Agricultural Experiment Station and industry associations provide raw materials of known history for this research.

Research on new and improved processing technology is conducted at New Orleans, Louisiana and at the U. S. Food Fermentation Laboratory, Raleigh, North Carolina. Pilot-plant investigations are being carried out at New Orleans on the production of a precooked dehydrated sweetpotato flake product to obtain engineering and other processing data applicable to commercial production. Processing variables being investigated include the effect of variety, curing, preheating, type of cooking, food additives and type of packaging. This work is closely related to the work of the Eastern Utilization Research and Development Division to improve the quality of processed potato products. The Marketing Economics Division, ERS (under a formal memorandum of understanding with the Southern Division, the Louisiana Sweet Potato Commission, the Louisiana State Agricultural Experiment Station, and the Louisiana State Department of Agriculture), conducts market tests on promising precooked dehydrated sweetpotato flake products to determine their consumer acceptance and market potential. In market tests to determine the type of package (can, glass jar or flexible pouch) that is best suited for retail market outlets for the flakes, Owens-Illinois Glass Co., Continental Can Co., and Lengsfeld Bros. are cooperating by providing packaging materials. Milprint, Inc. and Continental Can Co. are cooperating with the Southern Division in packaging studies to determine the structure of a flexible package required for flakes for the retail market. At Raleigh the objective of the research is to improve cucumber processing technology and the quality of the products. Current emphasis is on investigations of methods for the controlled fermentation of cucumbers by application of pure culture techniques to fermentation practices (including differential control of microbial species in natural fermentations by chemical and physical means) in order to reduce processing costs

and improve product characteristics. A hydrolytic enzyme inhibitor extracted from sericea forage is under investigation for the prevention of softening of cucumber brine-stock during the curing process. The North Carolina Agricultural Experiment Station is cooperating in the design and execution of experiments concerned with postharvest treatments to maintain or improve cucumber processing characteristics, and develop leads to improved methods of processing. The Michigan State University (Department of Microbiology) provides technical assistance in the controlled fermentation studies. The National Pickle Packers Association contributes support to the research and supplies raw material.

The Federal in-house scientific effort at the Southern Division devoted to research in this area totals 17.8 professional man-years. Of this total 2.1 is devoted to chemical composition and physical properties, 10.1 to new and improved food products, and 5.6 to new and improved processing technology.

The following line of work was terminated during the year: (1) Basic research on isolation and characterization of flavor and odor constituents of celery (under chemical composition and physical properties).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Identification and Characterization of Flavor and Aroma Components of Pickle Products. Basic research on the flavor and aroma components in natural and pure culture fermented cucumber pickle products was recently initiated in cooperation with North Carolina Agricultural Experiment Station, Michigan Agricultural Experiment Station, and the National Pickle Packers Association. It is planned to isolate, identify, and characterize these components to provide the basis for producing pickle products of greater consumer acceptability. Reliable methods for head-space sampling of foods for gas analysis and for measuring flavor components are being studied. Pure culture fermentations of cucumbers have been prepared for subsequent studies on flavor composition. These included duplicate 48-oz. jar lots using 34 lactic cultures representing four species (L. plantarum, L. brevis, Ped. cerevisiae and Leuc. mesenteroides). (S3 5-21).

2. Identification and Characterization of Flavor Constituents of Celery to Improve Processed Products. In fundamental studies of the composition of celery flavor and odor, a total of fifty-three of the sixty chemical compounds detected in distillates from expressed celery juice have now been isolated and identified. The total concentration of these compounds in celery juice is of the order of 0.5 to 1 ppm. A method for rapid essence recovery and flavor evaluation by a colorimetric ester test is being developed. Results have significance in that (1) identification of the major flavor contributing compounds will allow objective laboratory assessment of the effects of various processing conditions on the quality of manufactured

products and (2) a chemical test for total flavor, when completed, will provide a simple quality control procedure for use in industrial laboratories. Limited exploratory studies conducted on development of improved dehydrated celery stalk products indicate that flavor loss and toughness are problems involved. (S3 5-17, S3 5-23).

B. New and Improved Food Products

1. New and Improved Canned and Dehydrated Sweetpotato Products. Completed experiments on Goldrush sweetpotato flakes have confirmed previous findings that although combinations of antioxidants and synergists, including butylated hydroxyanisole, butylated hydroxytoluene, Tenox VI, α -tocopherol, citric acid and sodium pyrophosphate, extend shelf life of flakes sealed in air for a short time (48 days maximum), these additives are not sufficiently effective for commercial application. In other experiments, it was found that flakes could be readily processed from Centennial sweetpotatoes boiled in water, but flake storage stability in nitrogen was unsatisfactory. Flakes made from the Nemagold variety had a distinctive flavor and kept well when packaged in nitrogen but were not rated highly flavorwise. Flakes made from white varieties of sweetpotatoes were bland and starchy, yet were storage-stable in that they developed no hay-like flavor when stored in air for over a year. Flake products made from Goldrush by cooking in boiling water or in atmospheric steam above boiling water were acceptable and stable in nitrogen. Both cooking methods allowed the incorporation of solids ordinarily leached out and lost in steam cooking. The incorporation of sucrose up to 5%, dry weight basis, in the puree was found to improve the flavor and texture of "starchy" flakes. Packaging of the sweetpotato product in glass jars was shown to have commercial possibilities, especially for the retail market. Flexible packages may also have some promise if consistently gas tight packages can be attained. The sweetpotato product packaged with an oxygen content of less than 2% was shown to have the greatest storage stability. Antioxidant and synergist effects were minor in comparison.

Application of commercial amylolytic enzyme preparations in the "artificial curing" of freshly harvested sweetpotatoes shows promise of practical industry value as it may permit coordination of flake processing with canning, increases flake density, and enhances processability. Experiments employing five different commercial amylolytic enzyme preparations for conversion of starch of cooked puree from freshly harvested sweetpotatoes have shown promise in utilizing uncured sweetpotatoes for flake production. Greatly improved processing characteristics resulted when optimum time, temperature, and concentration conditions characteristic of each particular enzyme were used. Flake samples stored in nitrogen were quite stable for three months and panel evaluations were favorable. They indicated that the flavor of these flakes was "different" from those prepared from cured sweetpotatoes, but the general characteristic taste was

retained. Some samples have developed a slightly rancid or oxidized flavor after 6 months' storage. (S3 5-19).

2. Development of Modified Processing Procedures for New Varieties of Texas Vegetables. In continued green bean variety evaluation investigations, cooperative with the Texas Agricultural Experiment Station, 6 varieties and 3 strains of green beans were evaluated for desirable canning characteristics. The percent fiber in the pods of Pearlgreen, Abunda, B-3125-2-3-1, B-3489, B-3125-X-5-2 and Corneli 14 were above the .15 percent fiber tolerance allowed by the U. S. Standards for Grades of Canned Green Beans and Canned Wax Beans. Bush Blue Lake, Topmost and White Seeded Tendercrop were rated higher than the other varieties and strains because of lower fiber content in the pods. The exceptionally high fiber contents found in this past season's evaluations were due in part to several days of dry, hot south winds prior to harvest. Experiments with Pearlgreen variety green beans grown using different fertilizer treatments indicated it is possible to increase total yield of usable pods without sacrificing any of the desirable canning qualities of the pods by selected fertilizer application.

Limited effort has been made to develop a precooked, dehydrated carrot flake similar to the precooked, dehydrated sweetpotato flake. The bulk density of the carrot flakes is presently about 1/3 that of sweetpotato flakes and constitutes a major problem. Different kinds of hydrocolloids and other food materials and additives are undergoing evaluation in attempts to increase the bulk density of carrot flakes. Two experimental packs of carrot flakes have been canned in air and in nitrogen for stability studies at room temperature. One pack has no additive; the other contains salt. The experiments are still in progress.

Further experiments were conducted on firming the tissue of canning tomatoes in order to reduce peeling loss and increase drained weight. Homestead variety tomatoes (some with skins intact and some with skins pierced) were blanched in a 0.5% calcium chloride solution and canned. There was an average seasonal increase in drained weight of 5% attributed to better penetration in tomatoes which had had their skins pierced prior to blanching. The average increase in wholeness percentage was also slightly higher. The tests should be repeated using a 2% calcium chloride concentration in the blanch. (S3 5-16).

Research was initiated to apply newly acquired information on the chemical constituents of celery flavor to the development of processed celery products of improved flavor and convenience. Compounds pertinent to the flavor of celery have been found to be: 3-isobutylidene-3a, 4-dihydrophthalide; 3-isovalidene-3a,4-dihydrophthalide; 3-isobutylidene phthalide; 3-isovalidene phthalide; cis-3-hexen-1-yl pyruvate; diacetyl. The problems in dehydrating celery have been more specifically and clearly delineated in exploratory experiments. Fiber toughness in dehydrated celery appears to be associated with incomplete rehydration due to the

inability of the water to reach the interior portions of the pieces. The puffing technique of the Eastern Division has been investigated as a means of producing a more porous product with improved rehydratability. Small scale experiments indicated the technique may be of value, but conditions must be very closely controlled. Indications are that fiber toughness may be less of a problem with Pascal variety celery than with the Utah variety used earlier. Contrary to earlier observations, it has been found that detectable off-flavors do in fact develop during dehydration, in addition to the loss of the original flavor-inducing constituents through volatilization. Tests are in process of development which will be useful in the control of celery products and processing procedures. (S3 5-23).

C. New and Improved Processing Technology

1. Processing Investigations to Improve Quality and Reduce Costs of Canned and Dehydrated Sweetpotato Products. In pilot-plant studies of the production of precooked, dehydrated sweetpotato flakes, processing conditions have been established for making satisfactory flakes from cured sweetpotatoes of the Oklamor and Nemagold varieties. Additions of sugar and Mylase-P enzyme were required. Storage tests on the flakes have been initiated. Further work will be necessary on Centennial variety to develop satisfactory processing operations and a product with an acceptable flavor. Experiments conducted to evaluate pilot-plant scale processing of uncured Goldrush sweetpotatoes using enzymes showed that, although "good" flakes were produced, they were not considered comparable in taste to those produced from cured sweetpotatoes, and bulk densities were lower.

A cooperative institutional market test (SU, ERS, and Universal Foods) on the sweetpotato flakes, conducted in New Orleans, Louisiana, and Cleveland, Ohio, showed a highly favorable reaction to this new product by personnel and customers of the restaurants and other types of institutional outlets. In another extensive evaluation (2,000 participants), about 80% of the people liked the flakes as well as or better than fresh sweetpotatoes, and 90% liked them as well as or better than canned sweetpotatoes.

Cooperative studies to determine the structure of a flexible package required for flakes for the retail market are underway with Milprint Inc. and Continental Can Co. Results to date are very encouraging. Also, cooperation with ERS has been initiated to determine the type of package - flexible pouch, glass jar or metal cans - that is best suited for retail market outlets. Currently, flakes are being distributed commercially only to institutional outlets, whereas a major percentage of the U. S. food expenditures are in the household retail market.

Costs of precooked, dehydrated sweetpotato flakes produced at annual rates of 4.2 million and 14.6 million pounds in a hypothetical plant for processing 54,000 pounds of raw sweetpotatoes per hour were determined to be 50.0 and 36.9 cents per pound, respectively, using sweetpotatoes costing one cent per pound. This information was forwarded to industry for their consideration of commercialization.

Two plants are commercially producing the flakes at the present time. Although the initial plant has more than doubled its production for the 1962-63 season, total output for both plants is still considered small for sweetpotato processing plants. Plans for installation of a third plant have been announced by a third company. (S3 5-19).

2. Processing Investigations to Improve Quality and Reduce Costs of Fermented and Other Vegetable Products. Excellent progress has been made in the research to improve cucumber processing technology and the quality of the products. Formal cooperation is maintained with the North Carolina and Michigan Agricultural Experiment Stations, and the National Pickle Packers Association in this research. Earlier laboratory findings that the hydrolytic enzyme inhibitor (freeze-dried extract of sericea forage leaves) effectively prevents softening of cucumbers during brine-curing have been verified in small-scale brining tests (50-gallon drums) conducted in the field. The lactic acid fermentation and subsequent curing process developed normally in the inhibitor-treated lots, and the brine-stock was rated by a panel of plant operators to be highly acceptable for commercial use. Excellent results were obtained in blocking the softening action of added hydrolytic enzymes originating either from cucumber blossoms or from manufactured sources. In other work, it was found that pelletized freeze-dried lactic cultures can be used as effectively as broth cultures in making pure culture fermented dill pickles. Evaluation of these "semi-commercial" scale run dills after 5 months' storage showed that, in general, they rated "good" to "excellent" for acceptability for commercial use. Both of these developments offer promise for the production of superior pickle products, and for improving processing technology and reducing overall operating cost. (S3 5-20).

Assistance was given the Arkansas Agricultural Experiment Station in the evaluation of some new cucumber lines for brine-stock purposes. The brined cucumbers were evaluated for firmness, bloater content (hollow stock), color, shape, texture and overall acceptability for commercial use. The data will be used in rating the performance of breeding material as compared to known control cucumbers. This type of data is essential if better varieties are to be furnished the major cucumber growing areas of the country. (S3 5-16, S3 5-22).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

Arthur, J. C., Jr. and McLemore, T. A. 1963. The use of copper-64 in the investigation of reaction mechanisms of enzymes, particularly as related to food processing. "Production and Use of Short-Lived Radioisotopes from Reactors" II, pp. 247-259 Vienna International Atomic Energy Agency. Gold, Harvey J. 1962. Studies in the dehydration of celery. Proc. Florida State Hort. Soc. 75, pp. 336-342.

Gold, Harvey J. and Wilson, Charles W. III. 1963. Alkylidene phthalides and dihydrophthalides from celery. J. Org. Chem. 28, pp. 985-987.

New and Improved Food Products

Molaison, L. J. and Spadaro, J. J. (SURDD); Roby, M. T. and Lee, Frances H. (QMF&CI) 1962. Dehydrated diced sweetpotatoes--A pilot-plant process and product evaluation. Food Technol. 16, pp. 101-104.

New and Improved Processing Technology

Deobald, Harold J. and McLemore, Taylor A. July 24, 1962. Process for preparing a precooked dehydrated sweetpotato product. U. S. Patent No. 3,046,145.

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville, Maryland, and in Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 5.6 man-years is concerned with studies related to vegetables.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to horticultural crops are considered briefly in this report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutrient Values of Vegetables

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared," was completed and carried through to the galley proof phase. An extensive search has been made for data available on the composition of vegetables and products prepared from them. Some 80 vegetables (exclusive of potatoes) are included. The data are subdivided and presented in terms of over 400 items on the basis of the various factors found to be related to differences in values of important nutrients. These subdivisions include processing methods, such as canning, freezing, drying, cooking; state of maturity (lima beans, tomatoes); type (sweetpotatoes); and variety (squash)--if these factors significantly affect the composition of the vegetables. Many baby foods and some soups largely of vegetable content are included.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving Nutritive Value of Foods," Home and Garden Bulletin No. 90, is in press.

2. Vitamin analyses. Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in vegetables and other foods and to determine their overall distribution in the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B₆) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B₆ in food extracts and to verify results by comparisons with those of the microbiological assay.

An improved method for thiamine determination also has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thiochrome reaction.

3. Proteins and amino acids. A manuscript was published describing a method developed for assay of alanine using Leuconostoc citrovorum 8081 and providing data for 48 proteins and foods including lentils, lima beans, navy beans, red kidney beans, soybeans, blackeye peas, and green split peas.

Protein-rich mixtures of foods from vegetable sources are being developed and their nutritive values determined in contract research using Public Law 480 funds at Jerusalem, Israel. Chick peas were analyzed for content of total nitrogen and of the three amino acids (lysine, methionine, and tryptophan) which limit the nutritive value of most plant proteins. The values obtained were used as a basis for preparing eight mixtures expected to have relatively high biological values. The nutritive values of the eight mixtures, each prepared to contain 25 percent protein, were assessed on rats by determining protein efficiency ratio, digestibility and biological value, and net protein ratio.

B. Properties Related to Quality and Consumer Use of Vegetables

1. Preservation. Processing requirements for pickles and relishes made under home conditions were established, based on heat penetration measurements, microbiological examination, and taste panel evaluations. Physical and chemical changes during fermentation, processing, and storage were studied in relation to pickle quality.

Pickled vegetables, like other home-canned food, required heat treatment to destroy organisms that cause spoilage and to inactivate enzymes that may cause undesirable changes in texture, flavor, and color during storage. Adequate heating was best achieved by processing the filled jars in a boiling-water bath. When pickles were processed by the procedures recommended, the lethality values obtained in all cases were in excess of 36 minutes at 160° F., the amount considered necessary for bacteriological safety of the products.

All the pickled products in this study had pH values below 4.6, the pH considered critical in preventing growth of Clostridium botulinum and the production of toxin. Acid values changed very little as the result of processing or storing the pickles.

The salt content of the pickled products was about the same as that of the brine (3 to 5 percent). Only slight changes in salt content resulted from processing or storing.

Soluble solids content of fermented dill pickles ranged from 6.3 to 8.5 percent. Values decreased slightly with storage for fermented and fresh pack dills and dilled green beans. Crosscut pickle slices and sweet gherkins had soluble solids values from 30 to 45 percent. The values were not greatly influenced by processing or storage time.

Processed pickles were generally superior in flavor to unprocessed pickles after storage for periods up to 6 months. Retention of color and texture during storage of fermented dilled cucumbers was better for processed than for unprocessed pickles, but color and texture of the other pickled vegetables did not appear to be greatly influenced by processing. Application of the findings to household use have been made available to consumers and the technical results are being prepared as a bulletin.

2. Use of agricultural chemicals. Quality evaluations were made of sweetpotatoes grown by the Crops Research Division in untreated soil and in soil treated with the herbicide CIPC (isopropyl N-(3-chlorophenyl) carbamate), at the rates of 3 and 6 pounds per acre. The results indicate that CIPC soil treatments did not affect flavor and texture, but slightly changed the color of tubers grown in the treated soil. Although no statistically significant differences were found by the judging panel between color of the sweetpotatoes grown in untreated soil and those grown in CIPC-treated soil, several significant differences were found when measurements were made by the color difference meter. (1) The untreated sweetpotatoes were more gray in color than those grown in either 3 or 6 pounds per acre CIPC-treated soil; (2) the sweetpotatoes grown in 6 pounds per acre CIPC-treated soil were significantly less red in color than the sweetpotatoes grown in untreated soil. Those grown in 3 pounds per acre CIPC-treated soil were also less red in color than the tubers grown in untreated soil, but the difference was not significant. There were twice as many panel comments of greenish-yellow color in each of the treated samples as in the untreated but the differences in panel mean scores were not statistically significant.

3. Foreign community feeding programs. Directions for using U.S. Department of Agriculture donated commodities were developed and adapted for use in community feeding programs in Central and South American countries. Formulas and procedures were designed for 5, 50, and 100 portions, and directions were released in leaflets published by the Department of State.

4. Food buying guides for school lunch managers. A revision of PA-270, "Food Buying Guide for Type A School Lunches," was completed in cooperation with the Agricultural Marketing Service. New data were added to the 1955 edition and the format was changed to make the guide more usable by school lunch managers participating in the National School Lunch Program.

5. Food buying guides for families. Work has been initiated on a food buying guide for family use.

C. Nutrient Functions

Carbohydrates. Basic research using small animals and microorganisms is contributing to an understanding of the influence of type of carbohydrate on lipid and protein metabolism and to our knowledge of factors influencing the physiological response to carbohydrate-containing foods such as the legumes.

Protein components in the blood serum of rats, particularly rapidly moving components (PA), varied with diet and with age. PA was present more often and in larger amounts with fasted rats fed a sucrose-containing diet than with rats of comparable age on a starch-containing diet. With either carbohydrate (sucrose or starch), more PA was generally present in the serum of 350 day-old rats than in that of 150 day-old animals. With glucose, PA was present in small amounts in a larger percentage of rats, and no age effect was apparent. The percentage of 150 day-old sucrose-fed rats with serum containing PA was higher in nonfasted than in fasted rats; the reverse was observed with glucose. Lipid material was found in the PA components. The presence and amount of these components may provide an additional means of measuring response to diet and may prove a valuable tool for studying lipid transport.

D. Requirements for Nutrients

1. Preadolescent age group. Cooperation has continued with experiment stations in the Southern Region (S-28 revised) for investigation of metabolic patterns and for assessing requirements for and utilization of selected nutrients by preadolescent children. In 1962, at Blacksburg, Virginia, 12 preadolescent girls were maintained on controlled diets with variation in the amount of protein (entirely from plant sources). Analyses completed for intake and outgo of fat suggest that the amount of fecal fat excreted by the subjects was about twice the amount of fat excreted by subjects on controlled diets in earlier studies, where the protein was mainly from animal sources, although the content of total fat in the diets was comparable.

2. Adolescent age group. A study of nutritional needs of adolescents was conducted under contract at Berrien Springs, Michigan, with a group of adolescent girls, 16 to 19 years of age. The controlled diet used was designed to measure the metabolic response to an ovo-lacto-vegetarian type of diet. The major portion of the dietary fat was provided by butter and corn oil. The study will provide data on intake and outgo of nitrogen, fat, and selected minerals, and on blood lipid patterns for use in assessing nutritional requirements of adolescent girls. To obtain data for a more representative group of girls on an ovo-lacto-vegetarian type of diet, a replicate study is being planned with another group of 16 to 19 year old girls. Long-range plans include studies with younger adolescents using controlled diets with different combinations of food and different levels of nutrients.

E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was \$8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service, as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U.S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions", instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition," through filmstrips (Food for the Young Couple), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions," has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U.S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutrient Values of Vegetables

- Warren, H. W., Horn, M. J., and Blum, A. E. 1963. Microbiological determination of alanine in proteins and foods. *Analytical Biochem.* 5(1), pp. 70-77.
- Toepfer, E. W. 1962. Procedure for chromatographic separation and microbiological assay of pyridoxine, pyridoxal, and pyridoxamine in food extracts. Paper given at Committee on Vitamin B₆, Food and Nutrition Board, NAS-NRC, Denver, Colorado.
- Toepfer, E. W. and Zook, E. G. 1962. Problems in the microbiological assay for pantothenic acid. Paper given at the National Meeting of the American Society for Microbiology, Kansas City, Missouri.
- Hewston, E. M. 1963. Results of collaborative investigations of the thiamine determinations appeared in "International Zeitschrift fur Vitaminforschung" 33(1), pp. 1-17. Zur Standardisierung der Vitamin-B₁-Bestimmung in Getreide and Getreideprodukten-BB. B. Gassmann, J. Janicki, and E. Kamanski.

Properties Related to Quality and Consumer Use of Vegetables

1963. Making pickles and relishes at home. CA 61-14 Revised, USDA, ARS, HN, 16 pp. Processed.
1963. Rice and beans. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 7 pp.
1962. Sweeney, J. P. The protection of chlorophyll during cooking of green vegetables. The Cornell Hotel and Restaurant Administration Quarterly, 3(3), pp. 97-98.
- Bird, K. 1963. Palatability tests of freeze-dried foods. Marketing Research Report No. 617, 36 pp., illus. Human Nutrition Research Division cooperating.
- Harp, H., and Dunham, D. 1963. Comparative costs to consumers of convenience foods and home-prepared foods. Marketing Research Report No. 609, 91 pages, illus. Human Nutrition Research Division cooperating.

Nutrient Functions

- Lakshmanan, F. L. 1963. Factors influencing the presence of rapidly migrating serum protein components, PA. Federation Proc. 22(2), Part 1, p. 608 (abstract).

Food Consumption and Dietary Levels

Consumer and Food Economics Research Division. 1963. Food consumption and dietary levels of households of different sizes, United States--by region. Household Food Consumption Survey 1955, Rpt. No. 17. 168 pp.

Adelson, S. F. and Keys, A. 1962. The diet and some health characteristics of 123 business and professional men and methods used to obtain the dietary information. ARS 62-11. 280 pp.

Nutritive Value of National Food Supply

Consumer and Food Economics Research Division. 1962. Nutrients available from civilian consumption per capita per day 1935-39 and 1947-49 averages, 1960, 1961, and preliminary estimates for 1962, with percentage comparisons. Table 4. Nat. Food Sit. Oct. p. 22.

Consumer and Food Economics Research Division. 1962. Nutritional review. Nat. Food Sit. Oct. pp. 21-25.

Food Management Practices

Redstrom, R. 1962. Consumer practices in handling and storing of commercially frozen foods. In Family Economics Review, ARS 62-5. Sept. pp. 3-7.

Development of Food Budgets and Other Basic Data for Food and Nutrition Programs

Consumer and Food Economics Research Division. 1962. Estimated cost of 1 week's food. In Family Economics Review, ARS 62-5. (U.S.A. average issued quarterly, estimates for four regions issued annually.)

Consumer and Food Economics Research Division. 1962. Food for the young couple. Home and Garden Bul. No. 85. 16 pp.

Cofer, E., Grossman, E., and Clark, F. 1962. Family food plans and food costs, for nutritionists and other leaders who develop or use food plans. Home Economics Research Rpt. No. 20. 54 pp.

Consumer and Food Economics Research Division. 1962. Proc. of nutrition education conference, Jan. 29-31, 1962. Misc. Pub. 913.

Nutrition committee news (periodical, 6 issues): July-Aug. 1962, Sept.-Oct. 1962, Nov.-Dec. 1962, Jan.-Feb. 1963, Mar.-Apr. 1963, May-June 1963.

Phipard, E. F., and Page, L. 1962. Meeting nutritional needs through food. Borden's Review of Nutrition Research 23(3): 31-44.

III MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY

Market Quality Research Division, AMS

Problem. Vegetables are subject to deterioration after harvest through normal and abnormal metabolic changes and by decay organisms. In addition they vary widely at harvest in the characters that determine market acceptance. Much additional information is needed on objective indices for harvest maturity, quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels. Research aimed at the reduction of wastage during marketing is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Consistently safe and effective transportation of the more perishable products can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments.

USDA PROGRAM

The Department has a continuing program of applied and basic research relating to measurement, protection, and improvement of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Maryland; Fresno, California; Miami, Florida; Orlando, Florida; New York, N. Y.; Chicago, Illinois; and Harlingen, Texas and at the North Carolina Agricultural Experiment Station in cooperation with this station. The work on lettuce precooling is conducted in cooperation with the Grower-Shipper Vegetable Association and the Western Grower's Association who contribute financial support to the program.

A total of 15.0 federal professional man-years is devoted to this program. Of this, 2.0 are devoted to objective measurement of quality, 3.0 to quality maintenance in handling and packaging, 0.5 to quality

maintenance in storage, 2.0 to quality maintenance during transportation, 3.0 to postharvest physiology, 4.0 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the reporting period included: Decay and quality of California globe artichokes, mode of action of bacterial soft rot, relation between field temperature and russet spotting of lettuce, transportation and marketing Western melons, transportation in mechanical refrigerator cars, loading patterns and icing practices on celery and peas, hydrocooling vine-ripened tomatoes, packaging and storage of beans, improved packaging of mature-green tomatoes, quality changes in apples and onions during marketing, tomato fruit tumor, handling and packaging cauliflower and prepeeled onions, and decay of prepackaged carrots.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. The new USDA Sweetpotato Skin Color Chart was improved. An individual color for each leaf of the fan can now be placed on a root and direct color comparison made through a hole in the color area. Color fans have been furnished to sweetpotato breeders in North Carolina, South Carolina, Georgia, Mississippi and Louisiana for experimentation.

2. Tomatoes. Evaluation of the new USDA inspection procedure and the USDA Tomato Colorimeter continued in a number of locations. One of the principal tomato products manufacturers used the procedure exclusively in their purchase of tomatoes for manufacture in the Mid-West. Other large commercial concerns continued with the experimental evaluation of the new procedure and Tomato Colorimeter.

B. Quality maintenance in handling and packaging

1. Dry Beans. A study was made to determine whether multiwall paper bags are as satisfactory as burlap bags for handling and storage of 100 pounds of dry edible beans at country points and terminals. No significant changes in fat acidity and moisture content of the beans were found in any lot during storage. Sampling of beans in paper bags was performed in the normal manner by probing. A special pressure sensitive tape was used to seal the paper bags which had been torn during probing. Every multiwall and burlap bag was inspected after the 10-month storage period and found to be in good condition. Multiwall paper bags seemed to bridge areas better than burlap and hence stack more evenly. This work has been completed.

2. Cauliflower. Three tests were conducted in New York with pre-packaged cauliflower cooled in a commercial vacuum-cooler. Prior to cooling, the heads were treated with: (1) 100 ppm sodium hypochlorite; (2) 1 percent sodium acid sulfite; or (3) 1 percent acetic acid. Vacuum-cooled, non-treated heads were used as controls. The average temperature of the heads was reduced from 67° to 42° F. during vacuum cycles of 40 to 50 minutes. After a short transit period and 3 days at 45° F., discoloration of bruised areas lowered the quality of the heads. None of the chemical treatments maintained the appearance of the heads during a 2-week holding period at 45° F. A small-scale exploratory study at Beltsville showed that brief hot-water treatments (2 minutes at 90° F., 1 and 2 minutes at 125°, 1 minute at 130°, and 30 seconds at 140°) before packaging were without value in preventing darkening or reducing spoilage of segmented cauliflower. This work has been completed.

3. Lettuce. A wilted and discolored condition of the outer leaves was occasionally observed in retail stores in lettuce wrapped in heat-shrinkable film. In several tests in New York similar damage was produced by subjecting film-overwrapped heads to commercially applied heat-tunnel temperature of 285°-390° F. Heat-tunnel exposure times ranged from 1.7 to 5 seconds, the periods required for adequate shrinkage of the films used. Leaf damage occurred only in lettuce in the heat-shrunk films. Hard or overmature heads were most susceptible. Heat injury, besides affecting appearance, predisposed lettuce to decay.

4. Prepeeled Onions. Prepeeled, whole and sliced onions were packaged at the New York laboratory in perforated and non-perforated polyethylene bags. The whole, peeled onions held up well for 1 to 2 days at 70° F. and for about 9 to 14 days at 41° F. The shelf life of sliced onions was about one-half as long. Excessive watersoaking of sliced onions was prevented by slicing them over 1/8-inch thick. Off-odors and off-flavors were noted in some non-ventilated bags after 2 days at 70° F. This work has been completed.

5. Rhubarb. Tests were continued at Beltsville to determine shelf life of prepackaged cut rhubarb. Ways to prevent splitting and curling of outer layers, discoloration of cut surfaces and soft rot were tested. Rhubarb cut into 1-inch pieces and packaged in perforated (30 1/4-inch holes) 10-oz. polyethylene bags held up well for 2 to 5 weeks at 32° F., or for 3 to 7 days at 32° with an additional 1 day at 70°; for 7 days at 40°; for less than 3 days at 50°; and for 2 days at 70°. Rhubarb pieces packaged in polyethylene bags perforated with 30 1/4-inch holes held up slightly better than those in bags perforated with 2 1/4-inch holes. Drying cut ends in air before packaging helped prevent splitting of cut ends. Dipping cut pieces in 1 molar sucrose solution or 1 molar salt solution for various times up to 10 minutes greatly reduced splitting. However, after 2 days at 70° damage from

the sugar and salt solutions appeared.

Tests with whole stalks of rhubarb showed that unwrapped bunches with leaf blades on remained salable for less than 1 day at 70° and for less than 3 days at 32°. Unwrapped bunches without leaves lasted 3 to 7 days at 32° and 1 to 2 days at 70° with slight loss of turgor. Polyethylene-wrapped bunches of rhubarb with leaf blades on lasted 5 days at 32° plus 1 day at 70° or 7 days at 32°. Polyethylene-wrapped rhubarb without leaves lasted 7 days at 32° plus 1 to 3 days at 70°.

6. Sweetpotatoes. In 7 truck shipments from North Carolina to Chicago, Ill. a loading pattern for corrugated fiberboard cartons was developed which reduced temperature variation within the load from the usual 15 or 20 degrees F. to 10 degrees or less. Air circulation was improved and hazard of chilling reduced during the winter months. After 8 days in the market roots shipped in corrugated boxes had about 5 percent decay. Decay of sweetpotatoes shipped in bushel baskets with excelsior lid cushions averaged about 8 percent and roots shipped in baskets without lid cushions averaged 14 percent decay. These corrugated boxes cost about 10 cents less per container than the commonly used veneer boxes or baskets.

Of 7 lid cushions and 2 basket liners tested to reduce injury and decay none gave better results than excelsior lid cushions and paper strip liners. Cushions reduced decay an average about 25 percent as compared with no cushions.

Packaging tests with freshly harvested roots confirmed data obtained last year. Treated roots packaged in perforated polyethylene bags, polymesh bags and in trays overwrapped with shrinkable films more than doubled the sales of sweetpotatoes, as compared to bulk displays, in Raleigh, N. C. stores. Weight losses from roots in bulk displays and in polymesh bags were 2 to 3 times greater than from roots packaged in perforated polyethylene bags. Weight loss from tray-packed roots was usually intermediate but could be controlled by type of wrap (sleeve vs. overwrap) and type and width of film. Several packing-houses now treating with sodium orthophenylphenate are packaging sweetpotatoes commercially. Weight loss and root temperatures were similar in sweetpotatoes stored in palletized field boxes, bulk pallet boxes, or bushel baskets.

7. Vacuum Cooling. The relation of evacuation time to final temperature was determined in California for shrink-wrapped iceberg lettuce, lettuce in conventional cartons, film-wrapped trimmed cauliflower, and prepackaged ("cello") celery hearts vacuum cooled to various final absolute pressures. In general the vacuum cooling time was shortened by evacuation to 4.0 Mm. Hg. compared to the usual practice of breaking the vacuum at 4.6 Mm. Hg. The lower pressure

did not result in freezing injury when the produce was cooled in the usual shipping containers.

Commercial shrink-wrapped lettuce cooled as well as the conventional pack. However, cooling was dependent on an imperfect seal at the butt of the head and the openness of the pack, which allowed easy egress of moisture. Perforating the film wraps or the prepackaging bags improved the cooling.

C. Quality maintenance in storage

1. Asparagus Plants. Second year yield data at Beltsville indicate the following results of prestorage root trimming of asparagus planting stock.

Plants with roots trimmed to 4 inches or 8 inches from crown or untrimmed had similar yields, when such plants had been packed in polyethylene, stored at 32° F., and planted immediately after storage. Plants trimmed to 8 inches, stored in burlap bags at 32°, and planted immediately upon removal from storage had higher yields than those trimmed to 4 inches or untrimmed, or any of the polyethylene-packed lots (trimmed or untrimmed).

Delaying the planting by 6 days with the roots at 60° F. (assumed transit conditions) reduced the yield of all plants stored in polyethylene, but increased the yield of plants packed in burlap with the exception of plants trimmed to 8 inches.

2. Onions. California-grown onions held 2 to 5 weeks in common storage before transfer to 32° F. storage had 4 to 7 times as many bulbs with physiological breakdown after 4 to 7 months' storage as lots stored at 32° immediately after curing. This confirms previous results. Bulbs held 5 weeks in common storage before storage at 32° had 3 to 5 times as much breakdown after 4 or 5 months' storage as those kept only 2 weeks in common storage. After storage for 6 or 7 months, there was little difference between a delay of 2 or 5 weeks.

Covering the bulbs with soil during growth reduced the amount of breakdown from an average of over 4% in uncovered bulbs to below 2%. Onions that were covered in the field and stored at 32° F. immediately after curing were completely free of breakdown even after 7 months.

The rate of cooling onions had no effect on the amount of breakdown that developed in storage. Rapid cooling did not cause a physiological "shock".

Exposure of bulbs to modified atmospheres with 5, 10, or 30 percent CO₂ at temperatures of 50°, 86°, or 104° F. for 24 or 48 hours prior to cold storage had no effect on the amount of breakdown that

developed during 5 months' storage. Brief intra- and intercellular accumulation of CO₂ during high temperatures is probably not a factor contributing to physiological breakdown.

3. Sweetpotatoes. CIPC, applied as an aerosol, effectively controlled sprouting of sweetpotatoes. Taste panels could not detect differences between treated and non-treated roots which had been baked, or detect up to 10 ppm of CIPC added to reconstituted sweetpotato flakes.

D. Quality maintenance during transportation

1. Artichokes. The half-cooling time for size 36 globe artichokes completely exposed to the water in a flood-type hydrocooler was 8 minutes and for crated artichokes was 12 minutes. Nomographs for predicting cooling times and temperatures were prepared from the data. This work has been completed.

2. Asparagus. The response of asparagus to 8-day holding (to simulate a transit period) in atmospheres high in carbon dioxide (5, 10, 15, 20, or 30%) and low in oxygen (0, 1, 5, or 10%) was investigated further at Fresno, Calif. The low O₂ concentrations were tested because the use of liquid nitrogen as a refrigerant could result in atmospheres very low in oxygen in rail cars or trucks.

Asparagus held in 1% O₂ at 37° F. was almost free of low O₂ injury, but at 43° over 10% of the spears were injured. An atmosphere with five percent O₂ caused very little injury at either temperature. Complete lack of O₂ (100% N₂) injured the spears severely after 3 to 4 days. Low oxygen did not control soft rot.

Injury from CO₂ occurred at 43° F. in 10% concentrations regardless of O₂ concentration, while at 37° injury occurred only at 20 or 30% CO₂. Carbon dioxide injury was more severe at low O₂ concentrations (5 or 10% O₂) than at normal O₂ concentration (21%). Bacterial soft rot was reduced in proportion to CO₂ concentration at both 37° and 43° F. Control was almost complete in 15% CO₂ at either temperature, but this concentration was injurious at 43°.

These results indicate that asparagus should not be exposed to atmospheres containing less than 5% O₂ regardless of CO₂ concentration, or more than 10% CO₂ if O₂ is near 20%, or 5% CO₂ if O₂ is 10% or less.

Asparagus spears were hydrocooled in a flood type hydrocooler to determine the rate of cooling. The half-cooling time for spears completely exposed to the water was 1.1 minutes and for crated spears was 2.2 minutes. Nomographs for predicting cooling times and temperatures were prepared from the data.

3. Celery and Peas. The half-cooling time for California-grown celery completely exposed to the water in a flood-type hydrocooler was 5.8 minutes, and for that packed in a Sturdee crate was 9.1 minutes. The half-cooling time for peas completely exposed to the water was 1.9 minutes and for those in a wooden tub was 2.8 minutes. This work has been completed.

4. Lettuce. Transit temperatures of lettuce shipped in five conventional RS ice-bunker cars ranged from 36° F. to 39° F. with an average for all cars of 38°. (These cars were shipped under Standard Refrigeration with 2% initial salt and 4% salt added at each re-icing.) Average transit temperatures in three mechanically refrigerated cars ranged from 37° to 39°, essentially the same as those in the RS cars, but 3 to 5 degrees above the 34° thermostat settings. In one mechanical car, average trip temperatures of lettuce were the same in both ends of the car (37°). In two other mechanical cars, average trip temperatures varied by 2 to 3 degrees in opposite ends of the cars. Average trip temperatures in single-bunker thermostatically-controlled iced cars without bunker salt were 39° and 42°; in cars using 2 percent initial salt and 3 percent at each re-icing temperatures were 39° and 40°; and in a car using 3 percent initial salt and 5 percent at each re-icing temperatures averaged 37°. These single-bunker cars were equipped with metal air ducts extending beyond the doorway. These provided reasonably uniform temperatures in the 2 ends of the cars.

5. Tomatoes. California-grown tomatoes had a half-cooling time of 10 minutes when completely exposed to the water in a flood-type hydrocooler and 11 minutes when jumble stacked (5 layers high). Nomographs for predicting cooling times and temperatures were prepared from the data. This work has been completed.

A piggyback shipment of mature-green tomatoes from Florida, refrigerated with liquid nitrogen and controlled to the 5% oxygen level, was compared with a load shipped under mechanical refrigeration (60° F.). Commodity temperatures at arrival in the N₂ trailer were mostly above 80° with CO₂ in the atmosphere at 14%. Discoloration, pitting, and irregular ripening developed in the test fruit during ripening. Approximately 12% decay developed during ripening in comparison to 1% for fruit shipped under controlled 60° F. refrigeration.

E. Postharvest physiology

1. Russet Spotting in Head Lettuce. The data obtained during the past season in California on the relation between air temperatures during growth and the postharvest development of russet spotting confirm those previously obtained. In each of 3 years, air temperatures above 86° F., 9 to 14 days before harvest, tended to increase post-harvest russetting in lettuce that was so exposed during this maximum

growth period.

In several experiments at Beltsville the treatment of head lettuce with various antioxidants has given results ranging from nearly perfect control to no control of russet spotting. The variables responsible for the differential response have not been established.

Ethylene oxide, which has been found to counteract the effect of ethylene, retards the ripening of some fruits and the aging of cut flowers. At concentrations below 0.2% it did not prevent or delay russet spotting of lettuce. Concentrations above 0.2% with a treatment time of 18 hours induces an injury very similar to russet spotting.

2. Liquid Nitrogen as a Refrigerant. Experiments were continued at Harlingen, Texas to determine tolerances to atmospheres that might result with liquid nitrogen and carbon dioxide refrigeration. Atmospheres were maintained at 10, 20, and 30 percent levels of carbon dioxide; slightly less than 1, $2\frac{1}{2}$, 5 and 10 percent levels of oxygen with nitrogen; and air. Produce items were held 5 to 20 days in controlled atmospheres followed by 4 to 7 days in air at optimum temperatures. Responses varied considerably between items and treatments. Broccoli was not affected by any of the atmospheres. Cabbage showed severe internal browning when held in less than 1 percent oxygen and the high carbon dioxide levels were conducive to development of black leaf speck. Carrots in plastic bags developed a temporary "off" flavor in 30 percent carbon dioxide and a sweeter flavor in less than 1 percent oxygen. Celery developed an "off" flavor in 20 and 30 percent carbon dioxide. Butts of vacuum cooled lettuce showed the least discoloration in 20 and 30 percent carbon dioxide but severe internal browning occurred during subsequent holding. Sweet peppers showed an increase in pitting when held 5 days in reduced oxygen levels at 40°F. but no pitting occurred at 45°. Bacterial soft rot increased progressively with higher levels of carbon dioxide. Weight loss was greater in produce held in air than in the modified atmospheres.

Tests were also conducted at Beltsville with mature-green tomatoes. Quality was seriously affected by holding in a 100% nitrogen atmosphere at 60° F. for 7 days. When removed to air at 70° following treatment, ripening was retarded to such an extent that most fruits decayed before they were completely ripe. After holding in 99% nitrogen, tomatoes ripened when removed to air but at a slightly slower rate than tomatoes that were held in air. When fully colored, tomatoes held in 99% nitrogen were as firm as those in air.

F. Postharvest disease control

1. Carrots. Studies at Chicago on Geotrichium candidum, the organism causing "sour rot" of prepackaged carrots, have shown that it is favored by high temperatures and high humidity. The organism shows

marked tolerance to acid media and ability to acidify supporting media. A high percentage of germination occurred on water agar over the range of 50 to 95° F. during a 24 hour period. Spores held at 40° and 100° F. did not germinate. Carrot inoculations appear to be successful only when wounds are present with relative humidity near saturation and temperatures in the range of 70 - 90° F. The optimum temperature for growth on plates was 85°; the maximum temperature for growth was 100°. No growth occurred in 1 week at 40°. This work has been completed.

2. Chinese Cabbage. Soft rot of Chinese cabbage and other leafy vegetables was dependent on a given concentration of causal bacteria being present in the host in experiments conducted in Florida. With Chinese cabbage tissue, the lower the temperature between 80° and 40° F., the higher the concentration of bacteria needed to produce infection. The rate of growth of the bacteria, their metabolism, and their pectinase enzyme production influence their ability to cause decay. In culture, raising the temperature from 40° to 80° F. increased growth, oxygen consumption, and pectinase production by 4, 12, and 16 times, respectively. Concentration of bacteria is reduced rather slowly at 32°. It is important that vegetables susceptible to soft rot be cooled rapidly after harvest to prevent build-up of bacteria to a point where they will cause infection to vegetables following precooling and during transit to the market.

3. Escarole. The first evidence of breakdown of escarole is a physiological browning of leaf tips. This is followed by bacterial soft rot developing in this senescent tissue. Treating escarole with 10 ppm N⁶ benzyladenine delayed this physiological browning, thereby delaying the onset of soft rot. Treating escarole with N⁶ benzyladenine increased the shelf life by 2 days as compared with the untreated product.

4. Irradiation. Tomatoes exposed to a dose of 500 krad in the mature-green, breaker, or pink stage did not ripen normally (at 70° F.) At 250 krad red coloration was delayed and softening accelerated. Irradiation also increased susceptibility to chilling injury. Fruit exposed to 125 krad had more decay than either the checks or those treated with higher doses when the fruits were chilled 8 days (37° F.) after irradiation and then ripened at 70°. When the fruits were chilled only 4 days or not at all, almost no decay developed regardless of irradiation treatment.

Green bell peppers exposed to 500 krad were undesirably soft after holding 7 days at 37° or 50° F. Lower doses had no effect on firmness. After holding an additional 4 days at 59°, all those irradiated were softer than the controls; and the calyx of the treated pods became soft and discolored. The effect on the calyx was just discernible on a few pods exposed to 125 krad, but was severe on all pods at 500 krad.

Exposure to doses up to 375 krads had no discernible effect on cantaloupes when examined after 7 or 10 days at 38° F. However, after an additional 3 days at 59°, lots exposed to 375 krads had only 1/8 to 1/3 as many fruits affected by stem scar mold as the controls. The effect of 45 and 125 krads was inconsistent. Placing a piece of adhesive tape over the stem scar before irradiation reduced the incidence of stem scar mold greatly. The tape presumably prevented recontamination and subsequent infection. Irradiation had no consistent effect on flesh firmness.

5. Onions. In studies conducted in New York in cooperation with the New York Agricultural Experiment Station, dipping freshly harvested inoculated onions in 500 ppm Sorbistat solution decreased decay in storage. After 5 months' storage, treated onions had 18 percent decay while untreated onions had 25 percent decay. Maneb and Botran did not control Botrytis neck rot in storage. After 2 months in storage Downing Yellow Globe variety developed 4.9 percent decay when the plants were spaced in the field 7 per foot compared with 1.2 percent when they were spaced 12 per foot. The closely spaced onions had necks of smaller diameter which were less susceptible to decay.

6. Peppers. Tests at Beltsville showed that the Botrytis fungus readily infected bell peppers through wounds, but pods without wounds were not readily infected. Gray mold infection through wounds occurred at temperatures from 32° through 70° F. with greatest rate of decay on pods held at 70°. Unwounded pods held at high humidity became infected only at temperatures below 50°. Pods held 21 days developed several times as many lesions at 40° as similar pods held at 45°. This indicates that low temperature is the primary predisposing factor of bell peppers to gray mold rot.

In tests at Chicago, actual contact of spores with water films was necessary for infection by Botrytis cinerea. Inoculation of uninjured peppers at recommended storage temperatures (45 - 50° F.) were unsuccessful in absence of a moisture film even when spore germination had occurred. Inoculations of sound peppers by dusting with dry spores were unsuccessful. The presence of wounds or bruises facilitated infection.

A series of five tests was made in Texas to evaluate the effectiveness of different treatments, particularly hot water, for control of bacterial soft rot in inoculated bell peppers. The peppers were held 5 to 7 days at 70° at high relative humidity before final examination. Phytomycin, an antibiotic, very effective in earlier tests, and chlorine, commonly used in commercial treatments, were included in all tests for comparative purposes. Decay control expressed as percentage improvement over the untreated checks was as follows: (1) Phytomycin (100 ppm), 81%; (2) hot water (128° - 1.5 min.), 74%; (3) hot water (123° - 2.5 min.), 73%; (4) hot water (133° - 45 sec.), 56%;

- (5) sec-butylamine (1%), 23%; (6) chlorine (250 ppm), 17%; and (7) sorbic acid (5,000 ppm), 15%.

Hot water treatments resulted in slight to moderate surface pitting on some peppers in two tests. Reducing the exposure periods by 15 seconds nearly eliminated the occurrence of pitting without materially affecting the degree of control.

Hydrocooling increased the number of soft rot infections in 11 out of 12 lots. The increase ranged from 2 to 15 times that in comparable non-hydrocooled lots.

7. Sweetpotatoes. Screening tests at Raleigh, North Carolina indicate that Vancide 51 (sodium salt of dithiocarbamic acid and 2-mercaptobenzothiazole), now recommended for sanitizing grading equipment, will control soft rot and black rot without root discoloration or injury. Preliminary toxicity data, developed by the manufacturer, appear favorable for establishment of a residue tolerance.

In tests at Beltsville, Rhizopus stolonifer produced cellulase during growth in both artificial media and sweetpotatoes. The Rhizopus cellulase had optimum activity at about pH 4.8 and was partially resistant to boiling. The heat-resistant components had the same pH optimum as unheated preparations. Heating at 55° C. for 10 minutes destroyed the polymethylgalacturonase and macerating activity without inactivating the cellulase -- under these conditions no effect was observed on either the respiration or the macroscopic appearance of sweetpotato tissue. The respiration rate of normal sweetpotato tissue decreased in the presence of juice expressed from Rhizopus rotted sweetpotatoes. The effect on respiration was detectable slightly in advance of visible signs of tissue maceration. All attempts to separate a toxic factor from the macerating enzymes were unsuccessful. It is concluded that "killing in advance" of fungal mycelial penetration in the Rhizopus rot of sweetpotatoes is due to the action of the macerating enzymes.

8. Tomatoes. A variation in susceptibility to cold injury was found among tomato varieties grown in Florida and harvested at the mature-green stage. Tomatoes of the W. R. Grothan, Grothan Globe, Homestead, and Marion varieties had less *Alternaria* stem-end decay than those of the Indian River, Manapal, STEP 409, 410, and 430 varieties after 10 days at 50° and 40° F. In addition, tomatoes of the W. R. Grothan, Grothan Globe, Homestead, and Marion varieties ripened more rapidly than the other varieties at 70° F., either with or without a previous 10 day storage period at 55°, 50°, or 40° F.

9. Mode of Action of Bacterial Soft Rot of Vegetables. Previously a mutant strain with reduced ability to cause soft rot of several

vegetables was isolated in the New York Market Pathology Laboratory following ultraviolet light irradiation of the bacterial soft rot organism, Erwinia carotovora. The mutant strain has a slower growth rate and reduced pectolytic enzyme activity in host tissue which explains its reduced virulence. On nutrient agar, with or without tetrazolium, colonies of a virulent parent pathogen could not be distinguished from a weakly virulent mutant strain of Erwinia carotovora. Upon the addition of dextrose, levulose, or saccharose to nutrient agar, the smooth, large-sized colonies of the parent strain could be readily distinguished from the rough, small-sized colonies of the mutant strain. Colonies of the virulent strain on nutrient agar with sugar and tetrazolium were conspicuously redder than colonies of the weakly virulent mutant. Colonies of the two strains were indistinguishable when the nutrient agar was supplemented with pyruvate, citrate, or malate.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling and Packaging.

- Kaufman, J., Ceponis, M., and Michelstein, J. 1963. Effects of Chemical Treatment on Quality of Prepackaged Vacuum Cooled Cauliflower. Agricultural Marketing Service Report No. 506.
- Lipton, W. J., and Ceponis, M. J. 1962. Retardation of Senescence and Stimulation of Oxygen Consumption in Head Lettuce Treated with N⁶ Benzyladenine. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 379-384.
- Ringel, S. M., Kaufman, J., Ceponis, M. J., and Langlois, R. W. 1962. Some Quality Changes in Onions During Marketing. Agricultural Marketing Service Report No. 488.
- Stewart, J. K., and Barger, W. R. 1962. Effects of Precooling Method on the Quality of Crate-Packed and Prepackaged Celery. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 347-353.

Quality Maintenance During Transportation.

- Barger, W. R. 1963. Vacuum Precooling -- A Comparison of the Cooling of Different Vegetables. Marketing Research Report No. 600, 12 pp.
- Johnson, Howard B. 1963. Truck-Rail and Sea-Land Shipping Tests with Texas Fruits and Vegetables. Marketing Research Report No. 589.
- Moran, C. H., Hardenburg, R. E., Peel, R. D., and Moore, J. F. 1962. Commercial Packaging and Truck Transportation of Bare Root Tomato Plants in Polyethylene-Lined Crates. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 458-466.

Postharvest Physiology.

- Ryall, A. Lloyd. 1963. Effects of Modified Atmospheres from Liquefied Gases on Fresh Produce. Proc. 17th Nat'l Conf. Handling Perishable Agric. Commodities, pp. 21-24.
- Scholz, E. W., Johnson, H. B., and Buford, W. R. 1963. Heat-Evolution Rates of Some Texas-Grown Fruits and Vegetables. Jour. of the Rio Grande Valley Hort. Soc., Vol. 17, pp. 170-175.

Postharvest Disease Control.

- Friedman, B. A. 1962. Physiological Differences Between a Virulent and a Weakly Virulent Radiation-Induced Strain of Erwinia Carotovora. Phytopathology, Vol. 52, pp. 328-332.
- Friedman, B. A. 1962. Rate of Growth in Host Tissue and Virulence of Erwinia Carotovora. Phytopathology, Vol. 52, p. 732, (Abst.).
- Friedman, B. A. 1962. Changes in Virulence of Soft-Rot Bacteria During Laboratory Cultivation and After Ultraviolet Light Irradiation. Phytopathology, Vol. 52, p. 732, (Abst.).
- Segall, R. H., and Smoot, John J. 1962. Bacterial Black Spot of Radish. Phytopathology, Vol. 52, pp. 970-973.
- Spalding, D. H. 1963. Production of Pectinolytic and Cellulolytic Enzymes by Rhizopus Stolonifer. Phytopathology, Vol. 53, pp. 929-931.

TRANSPORTATION AND MARKETING FACILITIES
Transportation and Facilities Research Division, AMS

Problem. Returns to producers and prices paid by consumers for vegetables are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing vegetables. Such improvements are needed at both shipping points and terminal markets. They would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing costs, expand consumption, and reflect greater returns to producers.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. Continuing changes characterized the American marketing system. In protecting, distributing and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes.

It costs several billion dollars each year to transport farm products over the great distances between growing areas and consumers. In bridging this distance, products must normally be transported several times (farm to local assembly market, to warehouse, to terminal market, and thence to retail stores). Rail, truck, air, and water transport are used. Without this transportation, farm products would be worth little to farmers and nothing to consumers. Despite its importance, less has been done to improve the efficiency of transportation than for other aspects of marketing or farming.

USDA PROGRAM

This is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operating procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing vegetables. Vegetable research is conducted by the Washington office at both terminal markets and at shipping points. The Gainesville, Fla., and Athens, Ga., field offices also conduct work at shipping points, in commercial packing plants and in laboratory facilities of the University of Florida. Work at shipping points is in cooperation with the Florida, Georgia, and North Carolina Agricultural Experiment Stations on work at shipping points, and with the Market Quality Research Division, AMS. Work on terminal markets, covering the wholesale distribution, is conducted by the Washington office in the warehouses of selected fruit and vegetable wholesalers. The current annual Federal effort devoted to research in this area totals 12.3 professional man-years of which 1.3 is on vegetables.

Work on consumer packages and shipping containers is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of cost of materials and direct labor to pack, and their ability to reduce product damage and increase product salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) and investigate the needs for and benefits of container standardization and simplification. The program is carried on in cooperation with experiment stations and the industry in California, Florida and Washington, and at branch field stations Fresno, California; Orlando, Florida, and Yakima, Washington, and in the principal terminal markets. The professional man-years involved was 2.2.

The Department has a continuing program of economic-engineering research in agricultural transport. Its purpose is to develop improved transport facilities, equipment and services and more efficient means of using them in the production and marketing of agricultural products. Almost all the work is carried out in cooperation with various industry groups, trade associations, State Universities and experiment stations. Only one field station, Orlando, Florida, is permanently maintained for transport research. All other field work is carried out from the Washington office. Part of the research under this program is conducted under contract and cooperative agreements. The work on vegetables utilized 2.2 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Handling and Packing Vegetables

At Gainesville, Fla., a manuscript designed to reduce costs of packing mature-green tomatoes at shipping points was prepared. The manuscript covers container assembly, packing, weighing, closing, temporary storage, transporting via two-wheel clamp-type handtrucks, and loading for shipment. Time studies were made of assembling and handling containers to obtain data for the manuscript. Weights of packed boxes filled by automatic weigh-fill machines were checked to determine the error with this filling equipment. A statistical analysis was made of each sample to determine the standard deviation, weight variance, and average weight of containers filled at different packing rates.

Two major problems were encountered in the use of automatic weigh-fill tomato-packing equipment. Empty containers often fail to feed into filling position, or may fail to properly eject from the machine. Because of this failure, workers are stationed at each machine to insure the correct functioning of the container feeding mechanism. The other problem is weighing error or improper filling of the container. The present design of packing equipment, including tomato feeding devices, permit unweighed tomatoes to fall into the container before it is ejected. The machines, therefore,

must be adjusted to cut off at a weight slightly less than the final weight desired. When the expected number of unweighed tomatoes does not fall into the container prior to ejection, the container will be underweight. If more than the expected number falls into the container, it will be overweight.

A relationship was found between the average weight of a sample of containers and the rate at which the container was filled. As the number of boxes filled per minute increased, the average weight of the boxes also increased; when the number of boxes filled per minute decreased, the average weight decreased. Another relationship was found between the rate of filling containers and the variance of weight in the sample. As the number of containers filled per minute increased, the weight variance of the containers also increased. Further analysis of the data will be necessary to determine the weighing accuracy which might be expected at different rates of packing.

Work at a hydrocooling plant for packed celery revealed that an excessive amount of labor was being employed to move the filled crates through the flood-type hydrocooler. A new system of handling in unit loads was devised and tests were made of cooling these unit loads of packed crates with water. The results compared favorably with present flood hydrocooling methods.

During initial tests of cooling unit loads of crates, 2-1/3 gallons of water per square foot of cross-sectional crate area per minute were sprayed on the stack from an overhead full-cone nozzle. During later tests, nozzles were added to increase the water flow rate to 4½ and to 6 gallons per square foot per minute. The rate of cooling for the two and three nozzle tests was faster than when using a single nozzle at 35½ g.p.m. for each stack. However, there was no significant difference in cooling rate between the two higher flow rates. Additional tests were made to determine if redesign of the packing crates would improve the flow of water and the cooling rate. Tests were also made in a special hydrocooling research chamber to determine the heat transfer characteristics of celery and to determine the best cooling rate possible with 33°-35° F. water in a spray-type cooler.

Although data from all hydrocooling tests were not completely analyzed, the results which have been obtained show that it is possible to effectively hydrocool a unit load of 32 crates stacked 8 to a layer and 4 crates high. This type of cooling would permit use of more modern handling methods, reduce labor requirements, and improve product quality.

Labor costs for present methods of handling at the precooling plant are approximately 2½ cents per crate for unloading the field truck and for feeding the crates into the hydrocooling equipment. Labor and equipment costs to handle unit loads of crates at the precooling plant from the truck to the cooler by improved handling methods are estimated to be approximately 1/3 cent per crate; or a savings of about 2 cents per crate. This is a reduction in handling costs of about 80 percent.

Cooling Vegetables

This research at Gainesville, Fla., is designed to develop improved methods, operating practices, and techniques for use in existing and new facilities for more efficient cooling of vegetables. The research is directly related to that on the cooling of celery in unit loads previously reported.

Four precooling tests were run on potatoes, using forced-air as the precooling medium. These tests were run in the forced-air precooling chamber at the University of Florida at Gainesville. The results showed that the largest air to surface-of-tuber gradient was obtained with an air flow rate of about 2,000 CFM, or with a static pressure across the fan of about one inch of water. As long as the tuber surface temperature remained above 29° F., air at temperatures below freezing did not have an adverse effect. It appears that, from a practical standpoint, removal of field heat from tubers to 70° F. could be accomplished in a few minutes using very cold, subfreezing air.

Handling Vegetables in Pallet Boxes

1. Tomatoes. Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an urgent need for the development of larger containers than field boxes for handling this commodity. Because of this need, research on handling and ripening tomatoes in pallet boxes has been initiated at East Lansing, Mich., under a cooperative agreement with the Michigan Agricultural Experiment Station.

Research was conducted to obtain data on mature green, breakers, and ripe tomatoes which was useful in designing pallet boxes (or bulk containers) for handling, shipping, and ripening tomatoes. Three types of tests were conducted: (1) Drop tests onto panels of different materials with tomatoes of various ripeness; (2) panel-box tests with test containers of different depths and materials; and (3) bulk box studies of containers holding 500 to 1,000 pounds of tomatoes. In each of these tests the damage to the product was evaluated in accordance with standardized procedures.

As a result of these tests, 10 types of pallet boxes were designed. From these 10 preliminary designs, five types of pallet boxes were selected, details added, and modifications made. Three pallet boxes of each of the five types (plastic box, wire mesh, cardboard, wood No. 1, and wood No. 2) were constructed for the tests to be undertaken during the next report period.

Arrangements were made for the 1963-64 season with a shipper of tomatoes located in Florida and with several receivers in Michigan for the purpose of conducting handling, shipping, and ripening tests with the five pallet box types under commercial conditions.

2. Sweetpotatoes. This research is designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration. This work is being conducted at Raleigh, N. C., under a cooperative agreement with the North Carolina Agricultural Experiment Station and the North Carolina State Department of Agriculture.

Handling and curing tests were conducted with palletized loads of two types of field crates (Durabox and St. Francisville crate), pallet boxes, and a check study of bushel baskets. Results for the first year's test, which should be considered preliminary, indicate that sweetpotatoes can be as effectively cured either in pallet boxes or palletized loads of field crates as in hand stacked bushel baskets.

Investigations on bruising indicates that under static conditions, little or no damage is evident in sweetpotatoes under loads equivalent to a depth of five feet.

Work was accomplished on designing two closed air-handling systems for an 8- x 8-foot growth chamber--one to condition and move air for the growth chamber itself and the other to cool the lights and ballasts.

Records were kept of temperatures of the air inside a commercial storage and of the sweetpotatoes held in the storage. It was found that the desired temperature for curing (85° F.) never was attained during the first 14 days, neither was the temperature reduced rapidly enough to the desired storage temperature of 55° F. nor did the storage temperature reach this 55° F. level until after 14 weeks, when then it rose again above the desired temperature. During the storage period, the temperatures of both the storage and the sweetpotatoes fluctuated widely between 72° F. and 55° F.

A preliminary report covering the first year's research was prepared on "Pallet Boxes and Palletized Containers for Handling and Storing Sweetpotatoes:"

Handling and Packing Vegetables on Terminal Markets

1. Repacking Tomatoes. The purpose of this research by the Washington office was to: (1) Determine the relative efficiency of currently used methods and equipment; (2) develop more efficient methods and equipment; (3) determine the effect of handling different volumes on plant efficiency; and (4) suggest ways of reducing quality deterioration.

During the report period, work in this area was confined to the final editing of Marketing Research Report No. 597, "Tomato Repacking Methods and Equipment."

2. Tiering Devices and Equipment. This research also by the Washington office was directed toward reducing the cost of storing fruits and vegetables at the wholesale level by increasing the utilization of available storage space in wholesale fruit and vegetable warehouses.

The manuscript, "Storing Fruits and Vegetables on Pallets in Wholesale Warehouses," was edited for publication and forwarded to the Government Printing Office for printing.

3. Handling Operations for Multiple-Occupancy Facilities. The purpose of this research by the Washington office was to determine the combinations of crew sizes, operating methods, types of handling equipment, stacking or storage patterns, and facility layouts that will minimize the total cost of moving selected volumes of produce into, within, and out of modern multiple-occupancy buildings occupied by wholesale distributors of fruits and vegetables and reduce floor space requirements, and thus provide criteria to TFRD's Marketing Facilities Planning Staff for its work in specific areas or localities.

Work was limited to the completion of a "Survey of Fruit and Vegetable Wholesalers in Multi-Occupancy Facilities," covering 83 dealers in 11 cities in 10 different states. A summary has been prepared of the survey data, which include the business characteristic -- number of store units, annual sales, volume, seasonality of business, inventory, size, hours of operations, and services provide -- customer information -- type of customer, order size, and sale method -- and labor employed -- number of workers, wages paid, hours of work, crew size, and full or part-time workers.

Personnel assigned to this project have transferred and will not be replaced.

4. Loading Out Delivery Trucks. The purpose of this research is to evaluate and compare the relative efficiency of selected methods and types of materials handling equipment for order assembly and truckloading that are used by wholesale distributors of fresh fruits and vegetables supplying both affiliated and non-affiliated retail stores so as to reduce unit costs and minimize spoilage and waste.

This is a joint project of the Handling and Facilities Research Branch and the Wholesaling and Retailing Research Branch. Three basic types of loading out systems were studied in the warehouses of three wholesale distributors. The three methods include the use of: (1) A motorized belt conveyor with recording and transcribing equipment; (2) a motorized belt conveyor and checker system; and (3) a tow tractor and 4-wheel trucks to assemble individual orders. Preliminary analysis shows that the motorized belt conveyor with recorder and transcriber was less costly than other methods for the assembly of individual orders containing less than 55 packages. This system seems particularly suited for wholesalers supplying hotels, restaurants, institutions, specialty fruit and vegetable stores, and regular retail grocery stores. For wholesalers assembling larger than 55 packages per order, the tow tractors and 4-wheel selector trucks are the less costly. At the

end of the year, a manuscript entitled, "An Evaluation of Selected Methods for Loading Out Produce in Wholesale Warehouses," which summarizes the results of this research, was in preparation for publication.

Consumer Packages and Shipping Containers

1. Lettuce. The overall costs of marketing western lettuce can be reduced from 15 to 50 cents a box of 24 heads, if retailers who ordinarily prepackage lettuce in the store buy it already trimmed and wrapped at the shipping point. It costs 40 to 60 cents more per box to trim and prepackage lettuce in the production area than to pack nonwrapped heads the conventional way. However, this added cost is largely offset by lower transportation charges resulting from reduction of weight attained by trimming off the outer wrapper leaves before prepackaging. The overall savings come primarily from elimination of trimming and packaging in the store.

These figures are based on studies which began in 1961 after exploratory tests showed that lettuce prepackaged immediately after harvest in California and Arizona could be delivered to eastern markets in as good or better condition than the conventionally packed unwrapped lettuce.

From harvest field to retail store, prepackaged lettuce was compared with the conventional pack of nonwrapped lettuce. In addition to reduction of freight costs, advantages of prepackaging at point of production included these:

- *Increases the harvest volume of marketable lettuce under certain conditions.
- *Retards moisture loss and wilting, hence, extends shelf life.
- *Reduces amount of labor required to prepare and maintain displays.
- *Reduces waste and spoilage caused by customers handling displays.
- *Eliminates hazardous litter of broken leaves falling from displays into store aisles.
- *Increases the checkout efficiency.
- *Provides shoppers with a package that is dry and easily handled.

Some disadvantages of prepackaging are:

- *Costs more than packing nonwrapped heads.
- *Requires more and better trained labor to trim and wrap the heads.
- *Creates problem of what to do with "off-quality" lettuce in the harvested field; buyers expect only the best quality in any prepackaged commodity, hence, inferior heads must be excluded from the wrapping operation.
- *Minor defects seem to be magnified by the clear film wraps.
- *Results in brown, discolored butts.
- *Sometimes encourage careless handling; the package seems to cause some retail clerks to forget that lettuce is a perishable product which should be rotated in the display with extreme care, whether wrapped or nonwrapped.

The rather rapid increase in the volume of lettuce prepackaged commercially at shipping point in 1961-62 tended to lose momentum in 1962-63. This was attributed primarily to failure of some shippers to prepackage only top quality, and to irregular sizing of the heads.

Also, some consumers, accustomed to soft films, did not like the hard, brittle feel of polystyrene in which most of the early prepackaged lettuce was wrapped. To overcome this resistance, a new soft perforated polypropylene is being tested. Unlike polystyrene, the nonshrunk polypropylene wrap can be removed from the head by the housewife without damaging the film and can be used to rewrap any portion of the lettuce not needed at the time. The ability of polypropylene to protect the lettuce under adverse conditions has not been determined.

A manuscript has been prepared on the prepackaging of lettuce at point of production.

2. Sweet Corn. More than 10,000 test packages of sweet corn were shipped from Florida production areas to northern markets in April and May as researchers sought the best combination of materials and methods to provide consumers with a better product in a cheaper and more attractive package. The prepackaged corn was inspected on arrival in terminal warehouses and again in retail stores. Although much work remains, considerable progress was made. For the most part the packages consisted of five ears of partially husked corn cut to equal $8\frac{1}{4}$ -inch lengths, placed on a shallow pulpboard tray, and overwrapped with various transparent, shrinkable films. A strip of the husk was removed to reveal two or three rows of kernels for inspection by the buyers. Highlights of the findings included these:

- *Some types of film were unsuitable because of excessive fogging, wrinkling, or loss of clarity.
- *After a short time on display, corn which had been vacuum-cooled looked fresher than corn which had been hydrocooled.
- *Denting of the kernels did not occur in corn shipped in master containers to which package ice had been added. Some denting occurred in corn refrigerated only by top ice blown over the load.
- *Use of package ice also reduced discoloration of cut tip and butt ends after the corn began to dry out while on display.
- *Cut ends discolored more when the ears were shipped in a vertical position than when shipped in a horizontal position.
- *Loosening of the shrunk film wrap around the conventional pulpboard tray marred the appearance of the packages on retail display. Substitution of a moisture resistant tray, which did not wilt when wet, made it possible to maintain a neater, tighter pack.
- *Use of a paper liner in the shipping crate protected the packages from dirt and foreign materials, and helped preserve their fresh appearance.

- *The trimming and partial stripping in the production area reduced the weight of the corn, thus may reduce transportation costs.
- *Retailers liked the packaged consumer units better than the ones tested the previous year but declared that more improvements are needed before purchases on a commercial scale would be warranted.

Limited observations were made of a promising experimental package in which five ears were wrapped in film without use of a tray. Retail produce managers were enthusiastic about the neat appearance and the visibility of the corn from all sides. As yet, this package cannot be wrapped by machine and the manual wrap is too slow to be economically feasible.

New wax-coated cartons were compared with conventional wirebound crates for use as master containers. The test shipments, initiated near the end of the season, will be continued.

3. Asparagus and Celery. Asparagus was test packaged in California and Washington production areas and shipped successfully to eastern markets both by air and by rail. Two types of consumer packages included in the exploratory shipments protected the spears equally well. They were a stretchable film sleeve wrap and a folding wax-coated carton constructed without a cover to expose the tops of the upright stalks. The asparagus in the cartons stood on water-saturated pads which help maintain the moisture content of the stalks. The carton and pad cost 4 cents, about 3 times as much as the film sleeve. However, stretching the tubular film sleeve, inserting a bunch of asparagus, and releasing the tension to allow the film to grip the stalks was a slow process. Furthermore, unless the sleeve was carefully anchored down over the edge of the comparatively large butts, it tended to slide up over the smaller tips when being handled by shoppers at retail displays. More efficient methods of prepackaging the asparagus in both the film and the carton are now being explored.

A stretchable sleeve wrap, similar to that used on asparagus, is also being tried on celery stalks. Laboratory tests are being conducted to determine the effects of various films on extending the shelf life of the celery. Retailers want a package for celery, but they want the butt ends left uncovered to permit trimming when darkening occurs.

4. Cauliflower. Five types of film, both perforated and nonperforated, were evaluated as wraps for prepackaging Long Island cauliflower. In general, prepackaged cauliflower maintained a fresher appearance and tended to discolor less than nonpackaged cauliflower. Of all the experimental films, a shrinkable polyethylene without perforations performed best, and was comparable with the cellophane wrap in general commercial use. The initial shift to commercial prepackaging of trimmed cauliflower coincided with earlier research in California packing houses. Almost all western cauliflower now is prepackaged and growers in the eastern production areas are beginning to prepackage on a limited scale.

Earlier research developed a method of trimming off all inedible leaves, wrapping the curds in the heat-sealable cellophane, and packing in lightweight compartmented fiberboard boxes. Combined costs of materials, direct packing labor, refrigeration, and transportation for 100 pounds of edible cauliflower shipped from California to New York in the new packs ranged from \$7.10 to \$7.25. Comparable costs for shipping 100 pounds of partially trimmed, nonwrapped cauliflower in conventional wood boxes ranged from \$7.82 to \$9.23, depending on type of box and extent of trimming.

5. Tomatoes. Studies in a terminal warehouse showed that unit costs of prepackaging vine-ripe tomatoes were reduced 15 percent by increasing the size of the package. The cost of materials and direct labor to place 4 tomatoes in a 2 x 2 pattern in a shallow pulpboard tray and to sleeve wrap them in shrinkable polyvinyl chloride film was 1.51 cents per package. Comparable costs for 8 tomatoes in a 2 x 4 pattern were 2.57 cents a package. The cost of a master container was avoided because the same containers which brought the tomatoes to the warehouse were used to deliver them to retail customers. The cooperating wholesaler maintained strict quality controls and delivered the tomatoes to local stores the same day they were prepackaged. Store produce managers were well pleased with the packages, saying they all but eliminated spoilage losses and greatly reduced the time normally spent maintaining displays of bulk tomatoes.

Containers for Air Transport

A survey has been undertaken to pinpoint and evaluate the problems of packaging agricultural products shipped by air. Shippers emphasized the need for research to develop tough, lightweight packages and containers to improve the efficiency of handling and protect perishable commodities from exposure to unfavorable temperatures.

Tests were initiated to determine the feasibility of shipping asparagus, cut to 5-inch lengths, by air without refrigeration. This had been tried by rail and found unsuccessful because, after the inedible white butts had been cut off, the succulent green tips tended to decay. Laboratory observations indicated that prepackaged asparagus deteriorated more slowly than nonpackaged asparagus. Five air shipments of prepackaged asparagus were made--3 from Yakima, Washington, to eastern terminals, and 2 from Yakima to Fresno, California. The asparagus was sleeve-wrapped in a tube of stretchable plastic film and packed upright on moisture pads in a box with a film liner.

Asparagus in the West Coast shipments was without refrigeration less than 24 hours and was in excellent condition when inspected. Asparagus shipped cross-country was examined after 24, 48, and 72 hours without refrigeration. (The actual time these shipments were in transit, included pickup, waits at airport, flight, and delivery ranged from 24 to 36 hours.) The condition of the asparagus after 24 hours was "excellent" and it appeared "very

fresh;" after 48 hours the condition was reported "very good" and the appearance "quite fresh." Of two lots of asparagus from different shipments which were inspected after 72 hours without refrigeration, one held up well, with condition reported "good" and appearance "fairly fresh." The other upon close examination showed extensive slight decay in the tips and a lower incidence of slight to moderate decay in the butts. This asparagus was not considered saleable. The product temperature of both lots was 80° F.

Improved Loading Methods

Heavier Loading of Watermelons. All field testing has been completed on more than 90 all-rail and rail-piggyback shipments to determine the feasibility of loading long-type watermelons 6 and 7 layers deep compared with the conventional 4 and 5 layer loads. New cushioning materials and doorway retaining units were also tested and compared with the conventional straw or grass bedding and wooden door boards. Tests were made during four shipping seasons from major producing areas in Florida, Georgia, South Carolina, North Carolina, and Virginia to northern markets.

The results of heavier loads for two of the seasons studied were not comparable owing to unfavorable growing conditions which resulted in the production of melons of poor condition compared to those produced in normal seasons. The study as a whole demonstrated that shippers can take advantage of lower incentive freight rates or per-car rates through heavier loading of watermelons provided that proper precautions are taken to load only sound, disease-free melons of uniform size and not overripe. It was found that melon loads with lengthwise side wall rows alternated by layers make a tighter more compact load with less melon damage than solid crosswise loads.

A new polystyrene foam cushioning material of the proper grade, thickness and width, provides better melon protection than conventional straw or grass bedding. It is quicker and easier to apply and provides better air circulation to keep the melons cooler and reduce decay. Melons stay cleaner and drier, and the new material acts as a frictionizing agent which helps reduce sliding and bruising. A reinforced corrugated doorway retaining unit, which cost about the same as the conventional wooden door boards, was tested with generally good results. The unit is flush with the sidewalls of the car and helps to reduce melon damage customarily found adjacent to car doors when wooden door boards are used.

"Rail-piggyback" service in transporting watermelons from southeastern growing areas to northern markets has become very popular during the past two seasons. Destination inspection of seven "piggyback" trailer loads showed that watermelons stacked 8 and 9 layers deep sustained substantially less damage than melons stacked only 6 and 7 layers deep in standard rail cars.

All data have been analyzed and evaluated. The initial draft report of the results is being reviewed for publication.

Improved Baskets, Loading, and Icing Methods for Fresh Peas. All field work has been completed and most of the data have been analyzed and results evaluated on rail shipments of peas to determine the feasibility of using continuous stave baskets and less top ice on loads. Tests were made during two shipping seasons from major producing areas of California to eastern markets.

Compression tests were conducted on several different types of bushel baskets by the Forest Products Laboratory, Madison, Wisconsin. A comparison was made between the crosswise-offset alternately inverted loading pattern and the conventional bottom-to-bottom, top-to-top alternately inverted pattern. There were four tests in which the amount of top ice applied at shipping point was reduced from 22,000 to 10,000, and the amount of in-transit icing was proportionately reduced.

The results showed that both the continuous stave basket and the crosswise-offset alternately inverted loading pattern were effective in reducing container damage in transit.

It was also found that half stage bunker icing and less top ice at origin in conjunction with less top ice applied in transit will provide as effective refrigeration as heavier amounts of top ice. Container damage which generally results from caking and the overhead weight of excessive amounts of top ice was also reduced.

This research was carried out cooperatively, and the final report now being prepared will combine laboratory study material on baskets from the Forest Products Laboratory, field study material on icing methods and product temperatures from the Horticultural Crops Branch, Market Quality Research Division, AMS, with loading and transit damage data from the Transportation Research Branch, Transportation and Facilities Research Division, AMS.

New Air-Stacked Loading Pattern for Bagged Onions. The conventional loading pattern used for rail and motortruck shipments of onions packed in open mesh bags of 50-pound units do not provide adequate ventilation channels to cool the product during transit. In recent years rail carriers have introduced incentive rates to encourage heavier loading, and, to keep pace, highway trailers are being loaded to legal maximum axle limits. These developments have greatly increased the need for improved loading patterns to provide channels, or flues, for air to move freely through the load in larger amounts to more effectively prevent the accumulation of heat and moisture which promote the rapid development of decay.

During the past year three additional motortruck and 22 rail shipments were conducted from producing areas in Texas to eastern and mid-western markets to obtain additional information on a new experimental air-stacked

loading pattern. Several types of new cushioning materials were tested along with the conventional wood excelsior pads. Some of these may provide better product protection from physical injuries such as bruising from overhead weight and rubbing of bags against floor racks and side and endwalls of the vehicle.

The work conducted this year was completed in June 1963 and the data have not been compiled and analyzed to determine the results. The new air-stacked loading pattern increases approximately 75 percent the vertical and horizontal passageways for movement of incoming air through the load. The pattern was found to be relatively stable in transit and to provide somewhat lower product temperatures upon arrival at destination markets than the conventional tight-stacked loads.

This work will be continued during FY-64 to obtain additional data relative to the measure of load stability and relative effect in providing more favorable product temperatures and condition. Some future tests will include new types of cushioning materials. No information has been released on this work except restricted cooperator reports. No report is anticipated for publication until completion of the study.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Handling and Packing Fruits and Vegetables on Terminal Markets

Bogardus, R. K. and Lutz, J. M. 1962. Proper Storage Helps Keep That Farm Fresh Quality. SWD Bulletin, United Fresh Fruit and Vegetable Association, No. 228, November 15, 1962.

Bogardus, R. K. 1962. Signposts for Low Cost Handling of Fruits and Vegetables. Agricultural Marketing, Vol. 7, No. 12, December 1962.

Bogardus, R. K. 1963. Crew Organization Saves Dollars. Agricultural Marketing, Vol. 8, No. 2, February 1963.

Bogardus, R. K. 1963. Materials Handling Systems for Terminal Market Wholesalers. Paper presented at the Annual Convention, United Fresh Fruit and Vegetable Association, Los Angeles, California, February 11, 1963.

Meyer, C. H. 1963. Tomato Repacking Methods and Equipment. Marketing Research Report No. 597, September 1963.

Chapogas, Peter G. 1962. Prepackaging Lettuce at Shipping Point. Paper presented at annual meeting of Western Growers Association, Phoenix, Ariz. October 24, 1962.

Ginn, John L. 1962. Progress in Prepackaging Florida Vegetables. Paper presented at meeting of Florida State Agricultural Society, Miami Beach, Florida, October 30, 1962.

COOPERATIVE MARKETING**Marketing Division, FCS**

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 man-years are on the cooperative marketing of vegetables.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving celery marketing. Work was completed on a study of buying practices and preferences at the wholesale level for Florida and other celery in order to provide guides the Florida industry might use to improve its marketing efforts. Findings indicate that the industry should (1) carry out an internal educational program as a first step toward formulating a long-range marketing program; (2) initiate quality control procedures at the grower level; (3) develop a packaging program to enhance the appeal of the top grades; (4) direct advertising and promotional activities to the wholesale buyer as well as to the consumer; and (5) support further marketing studies, including research to develop celery appearance indicies and tests to evaluate arrival condition in the market. Preparation of a final report is underway. Work was done under contract with a private research organization.

Potentials in cooperative marketing. Work is underway to analyze the present status and trends in the cooperative marketing of fruits, vegetables and nuts, and to evaluate the potential of cooperatives for increasing their operating efficiency and market effectiveness through integration, coordination, consolidation, expansion or other means.

Cooperative bargaining. Work is being carried on to provide guides to growers and other segments of the processed fruit and vegetable industry in evaluating the potentials of this marketing method.

Coordination of marketing. A study was initiated to determine organizational characteristics and operating methods of selected joint sales agencies which market fruits and vegetables for member associations, evaluate their problems and possibilities, and develop guides for other cooperatives interested in a coordinated marketing program.

A case study is underway to evaluate and suggest improvements in the organizational structure and operations of a joint sales agency of vegetable processors in the North Central States.

Improving distribution of dry edible beans and peas by cooperatives. Work continued on evaluating ways in which selected dry edible bean and pea cooperatives can improve their marketing and distribution effectiveness. Preliminary results indicate substantial savings to farmers when storage is provided at either end of the distribution system rather than at some intermediate point. Additional savings accrue when packaging is performed near the point of production. This work is being done under contract with a private research organization.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Biggs, G. W. Jan. 1963. Vigor Added by Fruit and Vegetable Co-ops.
Article in News for Farmer Cooperatives.

McMillan, W. M. 1963. Proceedings of the Seventh National Conference
on Fruit and Vegetable Bargaining Cooperatives. FCS Unnumbered
Report.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers.

It includes work on market potentials for new products and uses; merchandising and promotion; economics of transportation and storage; economics of product quality; marketing costs, margins, and efficiency; market structure, practices and competition; and on information, outlook and rural development. In 1963 fiscal year, 7.5 Federal professional man-years were utilized in this work on vegetables.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Market Potentials for New Products and Uses

Vegetables. Sweetpotato flakes, a new convenient to use product developed by the Southern Utilization Research and Development Division, could help the declining market position of sweetpotatoes.

Initial research - an institutional market test - was completed in January 1963. Research results indicated a highly favorable reaction to the new product by the management, kitchen help and customers of restaurants and other types of institutional outlets. However, for the new product to influence consumption and ultimately, prices and production it must be promoted and distributed on a national scale. The latter is occurring. In the spring of 1962, only one firm processed sweetpotato flakes; today, there are three firms, and in addition, two more commercial plants are planned.

Because of the successful introduction of sweetpotato flakes in the institutional market, pilot research to investigate the potential of the product in retail food store outlets is underway.

Merchandising and Promotion

Increased Produce Sales Through Improved Merchandising. Work has been started to review research conducted by the Department and other sources on retail merchandising and promotion of fresh produce. From this review, research findings applicable to improved retailing of produce will be condensed, assembled, and made available to retailers, commodity groups, and others involved in distribution of produce.

Economics of Transportation and Storage

Fruit and Vegetable Transportation. The volume of fresh produce shipped interstate from California-Arizona production areas has remained relatively constant since 1951. Total traffic handled by both railroads and trucks has averaged about 350 thousand carlot equivalents annually. Approximately 60 percent of the interstate shipments from California-Arizona origins moves to destinations east of the Mississippi River. About 32 percent moves to points west of the River, while 8 percent is dispatched to Canada and Mexico. In 1951 rail carriers handled 87 percent of the shipments to United States outlets and 93 percent of the traffic routed to Mexican and Canadian destinations. Since then, rails' share of the annual volume shipped from California and Arizona to interstate markets has dropped to 70 percent and to 81 percent of the movement into Canada and Mexico during 1960. This loss by the railroads to trucks occurred primarily in that traffic moving to points west of the Mississippi River.

The ability of motortrucks to perform multiple pickup and multiple dropoff service, to make faster deliveries, and to offer greater flexibility for servicing less than truckload consignments were prime factors contributing to their success. Trucks are providing services that rails cannot duplicate economically.

The shipper survey phase of the two-part study is in manuscript form. The receiver phase will follow. Publication of the first phase is expected during the fourth quarter of calendar year 1963. Data are complete for the second phase.

Economics of Product Quality

Feasibility of Radiation Pasteurization. The Atomic Energy Commission is interested in determining if radiation pasteurization of fresh strawberries, peaches, citrus fruits, grapes, and tomatoes is economically feasible. Preliminary results of this study indicate that under present marketing practices product losses in marketing channels are as high as 15 percent. Interviews with representative samples of packers, shippers, and retailers of these fruits indicate a definite desire for extension of shelf life of these products, possible through radiation pasteurization, and a willingness to accept such products. The marketing firms interviewed indicated that the major disadvantage of the process probably would be consumer resistance, but that this might be overcome through an educational program. Work is now in progress on the developments of estimates of the cost of radiation pasteurization to assist the AEC in developing designs for suitable equipment and facilities. This research is a part of the AEC program for expansion of the peaceful uses of the atomic energy.

Marketing Costs, Margins and Efficiency

Marketing Margins. Marketing margins, retail prices, and farm values for fresh fruits and vegetables each increased 3 percent from 1961 to 1962. The farmer's share of the retail price for fruits and vegetables remained unchanged at 34 percent. Margins and prices for processed fruits and vegetables decreased. The farm value was down 12 percent, the retail price 4 percent, and the marketing margins 1 percent. The farmer's share of the retail cost dropped from 23 to 21 percent. A study of marketing margins for Washington Delicious Apples sold in Chicago and New York City showed the largest component to be the wholesale-retail margin. This margin claimed from 37 to 54 percent of the retail dollar in Chicago, and from 34 to 48 percent in New York City.

Market Structure, Practices and Competition

Competitive Position of the Western Fruit and Vegetable Processing Industry. The competitive position of the Western processing industry is affected considerably by intense competition from areas nearer major markets. Prices of many input factors, particularly labor and transportation, are higher in the West.

A comprehensive analysis of operating costs for multiple-product processing of selected vegetables by freezing shows that cost savings of from 10 to 20 percent are possible when compared with single-product plants.

The effect of length of operating season and plant capacity rate on total and average planning costs are presented. For example, one analysis shows cost savings of \$20 per 1,000 pounds in a multiple-product plant with an operating season of 2,000 hours over single-product plants for each of the commodities.

Changes in Structure of Wholesale Fruit and Vegetable Markets. Direct buying of fresh fruits and vegetables from shipping points by retail chains, together with increased prepackaging, have had serious effects on the structure of the wholesale market for fresh produce.

A final report summarizing changes in the structure of 52 wholesale produce markets has been completed. Direct purchases from shipping point by chains and affiliated groups increased from 12 percent of total market receipts in 1936 to 26 percent by 1958. During this same period the number of produce wholesalers decreased by 15 percent.

There is a shift toward more specialized markets for fruits and vegetables as reflected by changes in the types of fruit being handled by auctions located in terminal markets and by the increase in consumer packaging. In addition, in the produce industry there is a shift in emphasis from "trading" to "merchandising." Many firms are giving emphasis to performing marketing services contributing to orderly marketing rather than attempting to profit from short-term changes in prices.

Lower Rio Grande Valley Fruit and Vegetable Market. The U. S. House of Representatives and the fruit and vegetable industry of Texas have requested an evaluation of the structure and performance of the fruit and vegetable market in the lower Rio Grande Valley of Texas.

An analysis of the tomato market shows a highly competitive shipping-point market. An analysis of prices paid by chain and nonchain buyers shows no significant difference.

A comparison of prices received by growers with those reported by Market News found that the range of Market News prices reported included a large majority of the volume sold. For prices received by shippers, however, the upper point of the range of Market News prices was a better indicator of the high price than the low point of the range was in reflecting the low sale price.

A comparison of the change in packing cost associated with changes in quality of tomatoes when related to the spread between prices paid growers and the prices received by shippers (f.o.b.) showed the two to be closely related. This indicated a high degree of pricing efficiency.

Changes in the Structure and Performance of the California Fruit and Vegetable Industry. Changes in the market structure and practices in marketing fruits and vegetables grown in California require producers, shippers and wholesalers to adopt lower cost methods and practices.

Particular attention has been given to an examination of the assembly and distribution of fresh fruits and vegetables including mode of transportation and composition of shipments. From 1955 to 1961 transportation of fresh fruits and vegetables shipped out of California by truck increased from 20 to 30 percent of the total volume. In 1961, shipments in mixed loads accounted for 65 percent of all trucks inspected at order stations--averaging 5.5 different commodities per load.

Marketing Agreements and Orders. While Federal market order programs have operated for many years, little economic analysis of their operations or results has been made. Guides are needed for determination of the usefulness and probable effects of selected market order provisions for various commodities and marketing conditions.

Activity has been confined to preliminary investigations with respect to the five currently active Irish potato orders, the date order, and the suspended Florida tomato order. Questionnaires have been prepared for interviews of potato and date market order managers and administrative committee members and a sample of Florida tomato producers and handlers. Available secondary data concerning the potato and date orders are being studied.

Marketing Vine-Ripened Tomatoes. Marketing vine-ripened, winter green tomatoes is relatively new and has had a significant effect upon the operation of tomato repacking operations in receiving markets. Vine-ripened tomatoes provide an opportunity for wholesale firms (other than tomato repackers) to compete with repack tomatoes. About half of the receivers of tomatoes in major Midwestern and Eastern markets regarded the current system of grading vine-ripened tomatoes as inadequate. Two-thirds of these receivers reported that a major marketing problem was the wide variation in color among lots within a shipment. Most receivers believed that rigorous control of maturity together with more color uniformity would improve the efficiency of marketing tomatoes. These problems suggest a need for more coordination between producers and shippers in harvesting, handling, packaging and marketing so as to better satisfy market demand for vine-ripened tomatoes.

Information, Outlook and Rural Development

Feasibility for Establishment of Vegetable Processing Establishments in the Southeast

Vegetable processing is a small industry in the Southeast. Little is known concerning the economic conditions under which vegetable processing plants may reasonably expect to prosper in the South. Nevertheless,

vegetable growers, processors, public officials, and others have expressed a strong interest in determining whether processing plants can be economically feasible as market outlets for large quantities of vegetables grown in the Southeast. A considerable part of this interest stems from a strong desire to increase industrial development in the region. A survey of the vegetable processing industry in seven Southeastern States shows its major problems to be an inadequate supply of high quality vegetables for processing, price competition from other processors in selling the finished product, and financing the inventories of processed vegetables until they are sold. A case study of the feasibility of locating both a freezing plant and a canning plant in the Jackson County area of Florida yielded the following summary data:

<u>Item</u>	<u>Freezing</u>	<u>Canning</u>
Annual volume required	9.5 million pounds	585,000 cases
Initial capital investment required:		
Buildings and equipment	\$ 860,000	\$ 350,000
Annual operating capital	\$1,200,000	\$1,270,000
Net profit after taxes	\$ 109,722	\$ 77,301
Net profit as a percentage of fixed investment	12.76	22.08
Net profit as a percentage of gross sales	7.73	5.43

In addition, a study of market entry for a new processing plant into an established, adequately supplied market suggests a need for careful planning to combat the sharp competition. With good management, market introduction costs were estimated to be about 10 cents per case.

First Phase of Long-Term Outlook for Marketing Western Agricultural Products Relates to Fruits and Vegetables

Outlook for the marketing of fruits and vegetables for the 11 Western States was projected for the period 1975. These projections show a continued growth in the volume of these products and indicate that this western region should supply an increasing share of the total. The forecast is based on an expected increase of 31 percent in total U.S. population and some increase in per capita consumption per year. The West now supplies about 65 percent of noncitrus fruit, 45 percent of vegetables, and 28 percent of citrus fruits. Increases in the proportion of total supply of noncitrus fruits and vegetables, with a small decrease in the proportionate citrus fruits supplied by the West, appear in prospect. These changes can be viewed in terms of the total U.S. consumption increase projected for the period of approximately 33 percent above that of 1960.

The greatest growth including vegetable sales appears to be in processed products. The greatest growth in food and vegetable processing between now and 1975 is likely to be in freezing, combined freezing and dehy-

dration, and various improved methods of dehydration. In these areas processing has grown rapidly and is likely to continue to grow for the next several years, though possibly at a slower rate.

Long-Term Outlook for Industries Assembling and Processing Products of Agriculture in the Pacific Northwest

This research, by five-year periods between 1965 and 1980, will project the production and employment in establishments assembling and manufacturing products of agriculture. The geographical area covered will include the States of Washington, Oregon, Idaho, and western Montana. Projections for the statistical base period (1965) are near completion.

During the coming year extensive progress is anticipated in completing the series of five-year projections.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH**Market Potentials for New Products and Uses**

Dwoskin, P. B., Hester, O.C., Kerr, H. W. Jr., and Bayton, J. A.,
January 1963, Market test of instant sweetpotatoes in selected institutional markets, Marketing Research Report No. 580.

Economics of Product Quality

Droge, John H. 1963. Marketing feasibility of radiation pasteurized fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit. Published for the U. S. Atomic Energy Commission, Division of Isotopes. Development. ERS-131. August.

Droge, John H. 1962. Marketing feasibility study of radiation processed fruits and vegetables. Remarks prepared for presentation at the Second Annual U. S. Atomic Energy Commission Food Irradiation Contractor's Meeting in conjunction with the Sixth American Institute of Biological Sciences Advisory Committee Meeting on Radiation Pasteurized Foods. October.

Marketing Costs, Margins and Efficiency

Edman, Victor G. February 1963. Marketing margins for fruits and vegetables. Article in Marketing and Transportation Situation. (Reprinted as ERS-106.)

Market Structure, Practices and Competition

Bohall, Robert W. April 1963. The organization of the wholesale fruit and vegetable markets in Miami and Tampa-St. Petersburg. MRR-593.

Bohall, Robert W. April 1963. Texas tomato marketing. Talk presented at Texas Valley Tomato Committee.

Chapman, W. Fred, Jr. October 1962. The organization of the wholesale fruit and vegetable markets in Seattle-Tacoma, Portland and Spokane. MRR-563.

French, B. C. and Richter, J. A. November 1962. Cost and factor price changes in the vegetable producing and processing industries, 1947-61. California Agricultural Experiment Station ditto. (Supplement to Giannini Foundation Research Report No. 241, issued March 1961.)

Hutchings, Harvey M. and Davis, G. B. An economic analysis of interregional competition in the frozen pea industry. Technical bulletin of Oregon Agricultural Experiment Station in cooperation with ERS. (In press.)

Manchester, Alden C. June 1963. The changing market structure for perishables. Speech presented at Citrus and Vegetable Marketing Clinic, Lakeland, Florida.

Manchester, Alden C. October 1962. The organization of the wholesale fruit and vegetable markets in Detroit, Albany-Schenectady-Troy, and West Virginia. MRR-562.

Podany, J. C., Bohall, R. W., and Farrish, R.O.P. February 1963. Tomato prices and market structure in the Lower Rio Grande Valley of Texas. MRR-588.

Reed, Robert H. and Sammet, Loy L. July 1963. Multiple-product processing of California frozen vegetables. California Agricultural Experiment Station Giannini Research Report 246, in cooperation with ERS.

Reed, Robert H. and Boles, James N. July 1963. Nonlinear programming of field and plant vegetable processing activities. Agricultural Economics Research, Vol. 15, No. 3.

May 1963. Fruit, vegetable wholesalers are short-lived firms. Article in Farm Index, U. S. Dept. of Agr.

Godwin, Marshall R. and Manley, William T. March 1963. An economic evaluation of grade and size standards for mature green tomatoes. Florida Agricultural Experiment Station Bulletin 652, in cooperation with USDA.

Information, Outlook and Rural Development

Martin, Loyd C. February 1963. Role of processing in utilizing all grades of products. Remarks at the Joint Session of Marketing and Horticulture Sections of the Association of Southern Agricultural Workers, Memphis, Tennessee.

Stallings, Dale G. March 1963. Marketing western fruits and vegetables, long-term outlook. ERS-77.

Williams, Floyd W. July 1963. A case study in development of community resources. Speech given to the Florida Association for Vocational Agricultural Teachers at Daytona Beach, Florida.

_____. August 1963. The economic feasibility of establishing a vegetable processing plant in Jackson County, Florida. Special report of the Economic Research Service for the U.S. Department of Commerce Area Redevelopment Administration.

_____ and Allen, Melvin B. March 1963. Southeastern vegetable processors--marketing practices and management problems, 1960. Published in cooperation with the Georgia Experiment Station. Mktg. Res. Rpt. 583.

_____. Winter 1963. Vegetable processing in the Southeast. Article in Georgia Agricultural Research.

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

Producers, processors, distributors and consumers need better information on supplies, production and consumption of farm products, and the effect of these and other factors on the prices of these products. Similarly, Congress and the administrators of farm programs need to evaluate alternative proposals to modify existing price support and production control programs in terms of their impact on production, consumption and prices received by farmers.

USDA PROGRAM

Commodity Situation and Outlook Analysis

This work involves 1.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fresh and processed vegetables. Results of these appraisals, findings of special studies, and long-time series of basic data are published in quarterly issues of the Vegetable Situation, the National Food Situation, the Demand and Price Situation, and monthly in the Farm Index. A comprehensive analysis of the vegetable situation is presented at the Annual Outlook Conference. Presentations also are made at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special studies are made from time to time to determine probable effect of proposed programs on supply, price and consumption of vegetables. Basic statistical series are compiled, improved and maintained for use in statistical and economic analysis.

Supply, Demand and Price Analysis

This work involves 0.5 professional man-year located in Washington, D. C. The research is part of a comprehensive program of work designed to identify and measure factors influencing the supply of, demand for, prices, and utilization of fresh and processed vegetables, including dry edible beans and peas. Emphasis the past year has been on a study of economic aspects of the dry edible bean industry, including trends in consumption, shifts in patterns of production by classes, production response to price, and influence of government programs on consumption.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS**Commodity Situation and Outlook Analysis**

Total supplies of fresh vegetables, excluding melons, were moderately larger in the first half of 1963 than a year earlier. During the early weeks of 1963, prices of tender items, hard hit by winter freezes, were at high level. However, overall supplies of fresh items were larger in both winter and spring than in 1962, and prices to growers averaged lower from February through April. Summer production was down slightly from the previous year, and prices averaged higher.

Both canned and frozen vegetables were in generally heavy supply during the past year, with canned corn, tomatoes and tomato products extremely heavy. Because of an expected substantial cutback in the canned pack, and a moderate cutback in the frozen pack, supplies of both canned and frozen items probably will be moderately smaller in the 1963-64 season than in 1962-63. Prices both at f.o.b. and retail levels are likely to average a little above those of last season.

An article on the influence of the food stamp program on vegetable consumption was included in the January issue of the Vegetable Situation. The study, prepared in the Marketing Economics Division, disclosed that in both Detroit, Michigan, and rural Fayette County, Pennsylvania, families participating in the food stamp program increased their consumption of vegetables by $2\frac{1}{2}$ pounds per week from spring to January. This rise was more than the seasonal increase as measured by a control group of families. Increases of 15 cents in per capita weekly expenditures for vegetables in Detroit, and 9 cents in Fayette County were attributed largely to the new family purchasing power in the form of food coupons. Most of the increase in both quantity and value resulted from greater use of fresh vegetables. Frozen vegetable consumption also increased. Long-run projections (5 years) of production and consumption of vegetables were developed as part of a set of ERS projections for the economy as a whole.

Another special article dealt with long-time trends in production and consumption of dry edible beans. The study showed a generally rising trend in use of beans per person into the early 1940's. Partly because of a strong World War II and immediate postwar demand and heavy exports, a large part of which were lend-lease to our Allies, per capita consumption by the late 1940's had declined substantially, to less than 7 pounds. Consumption subsequently recovered somewhat, and in the last few years has averaged close to 8 pounds per person. Since the mid-1930's there has been a significant change in the relative importance of various kinds of beans. Actual output of lima beans declined and their relative importance fell sharply. Production of pintos, most important of the colored classes, is about triple that of the mid-1930's. Among white classes, production of Great Northern increased only about a fifth, but production of pea beans about doubled.

Supply, Demand and Price Analysis

A study of economic trends and Government programs for dry beans is nearing completion. It portrays a rapidly changing industry during the past 25 to 30 years. Although number of farms producing dry beans and total acreage declined substantially, advancing technology and improved cultural practices boosted yields sharply, and total production increased about 50 percent. Changes in demand, coupled with changes in acreage, and yield resulted in significant changes in the pattern of production. Colored beans as a group showed the sharpest gain, increasing from about a fourth of the total in 1933-36 to about 40 percent of the total in 1957-60. Actual output of white beans also increased over the period, but the group lost in relative importance from 50 to 44 percent of the national total. Lima beans declined both in actual production and relative importance.

Early in World War II support prices at 90 percent of parity were initiated for dry edible beans. Because of the strong demand both at home and abroad, virtually no beans were delivered under the support program. In the post-war years supports have varied from 60 to 90 percent of parity. Deliveries to the Commodity Credit Corporation were very heavy in 1948 (about 5 million hundredweight) and again in 1949 (about 6 million hundredweight). Deliveries from subsequent crops have been much lighter, averaging 1.6 million hundredweight in the years 1950-61, about 9 percent of total production. Of all beans delivered to CCC about 25 percent have been sold back into domestic markets, 15 percent disposed of through domestic donations programs, and 60 percent have been exported.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Commodity Situation and Outlook Analysis

Simmons, W. M. October 1962. Smaller retail sizes in canned vegetables gain in postwar period. Vegetable Situation.

Simmons, W. M. April 1963. Trends in dry bean consumption and production. Vegetable Situation.

Simmons, W. M. Vegetable Situation. Published quarterly. ERS, USDA, Washington, D. C.

DePass, R. E. January 1963. Influence of the food stamp program on vegetable consumption. Vegetable Situation.

CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D. C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years, of which 0.9 was devoted to work on sweetpotato products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A preliminary statement of results of a consumer panel test, released in April 1963, showed that dehydrated sweetpotato flakes won favor with many housewives. To learn consumer's reactions, researchers supplied a panel of over 200 households in suburban Washington, D. C. with samples of this new product, which was developed by the Southern Utilization Research and Development Division of the Agricultural Research Service. Panel members were requested to prepare the test product in two ways and to indicate their opinion on a rating scale. A majority of the women were at least moderately pleased with the flakes in both the recipes they tried, and praised the convenience of the new product in both dishes. However, the flavor of the more highly seasoned recipes--particularly pie--helped to boost the appeal of the flakes. Further evidence of the women's favorable opinion of the sweetpotato flakes is found in their comparisons of the new product with other forms of sweetpotatoes they had used. For example, a little better than half of those who had used fresh sweetpotatoes in the last year said they would prefer the flakes for making mashed sweetpotatoes. A large majority of the respondents said they would be interested in buying the test product if it were available locally. A more complete analysis and final report of the findings of this study is in preparation.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Dehydrated Sweetpotatoes Approved by Homemakers (A Preliminary Statement of Results of the Sweetpotato Flakes Consumer Panel Test).
Farm Index, April 1963. (S&R 3-5)

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